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	AIRCRAFT NUCLEAR COMPATIBILITY CERTIFICATION HANDBOOK

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This handbook provides the United States Air Force (USAF) Nuclear Weapons Center (AFNWC), The Department of Energy (DOE) National Nuclear Security Administration (NNSA), and Sandia National Laboratory (SNL) personnel with reference information for understanding the nuclear weapon compatibility certification process for USAF aircraft. This handbook references the aircraft compatibility certification portion of Air Force Instruction (AFI) 63-125, Nuclear Certification Program. Some information contained in this handbook was extracted from relevant Department of Defense (DoD), Air Force publications, and other documentation from SNL. This publication does not apply to Air Force Reserve Command (AFRC) or Air National Guard (ANG) Units. The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Air Force. Refer recommended changes and questions about this publication to the Office of Primary Responsibility (OPR) using the AF Form 847, Recommendation for Change of Publication; route AF Form 847s from the field through the appropriate functional's chain of command. Ensure that all records created as a result of processes prescribed in this publication are maintained in accordance with Air Force Manual (AFMAN) 33-363, Management of Records, and disposed of in accordance with Air Force Records Information Management System (AFRIMS) Records Disposition Schedule (RDS) located at https://www.my.af.mil/afrims/afrims/afrims/rims.cfm. See Attachment 1 for a Glossary of References and Supporting Information.

FORWARD

This handbook is approved for use by the Air Force Nuclear Weapons Center (AFNWC), Department of the Air Force, and is available for use by all Departments and Agencies of the

Department of Defense and the Department of Energy (DOE) National Nuclear Security Administration (NNSA), and Sandia National Laboratory (SNL). This Handbook describes the electrical and mechanical responsibilities for the tasks related to Aircraft Compatibility Nuclear Certification. The content of this Handbook elaborates on the aircraft compatibility certification tasks described in AFI 63-125, Nuclear Certification Program, MIL-STD-1822A, Nuclear Compatibility Certification of Nuclear Weapon Systems, Sub-Systems, and Support Equipment, and SAND2011-2981, Aircraft Compatibility Tasks Required for the Release of an Aircraft Compatibility Control Drawing. This Handbook is written in a mentoring way to help the reader understand all of the electrical and mechanical responsibilities associated with aircraft compatibility, and the criteria that measures the process elements leading to a successful and approved Nuclear Compatibility Certification Statement (NCCS), a released ACCD, and/or Compatibility Certification (CC) Drawing. Comments, suggestions, or questions on this document should be addressed to AFNWC/EN, Attn: Andrew Rogulich, 1551 Wyoming Blvd. SE, Kirtland AFB, NM 87117-5624 or emailed to (**andrew.rogulich@kirtland.af.mil**). Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at **www.dodssp.daps.mil**. If assistance is needed in understanding the details of this Handbook, the following people may be contacted: Andy Rogulich, 505-846-4740, AFNWC/EN, **andrew.rogulich@kirtland.af.mil**; Dan Granados, 505-846-4615, AFNWC/498NWAS; **daniel.granados@kirtland.af.mil** or Larry Stevenson, 505-845-9681, SNL/2951, **lesteve@sandia.gov.**

1. Scope. The information in this Handbook describes a way of learning and dealing with the aircraft nuclear compatibility certification tasks required by the AFNWC, NNSA, and SNL. This handbook is for guidance only and cannot be cited as a requirement.

2. Introduction. To structure the information in this Handbook, the tasks defined in AFI 63-125, MIL-STD-1822A, and the SNL Report entitled, Aircraft Compatibility Tasks Required for the Release of an ACCD (SAND2011-2981) have been italicized. This Handbook will help the reader understand what the job/task is and what needs to be done to complete the aircraft compatibility certification task.

3. Definitions. The AFNWC at Kirtland AFB, NM and Ramstein AB, GE, and the SNL Aircraft Compatibility Department are made up of staff members with electrical and mechanical backgrounds. The Nuclear Systems Division of the AFNWC has two main Sections within the Surety and Effect Branch which are responsible for aircraft compatibility activities. The Nuclear Surety Section has staff assigned to handle, aircraft compatibility, AMAC testing as defined in the 498 NSW OI 99-01, nuclear safety, and nuclear weapon-related Technical Orders (TOs). The Certification Management Section handles nuclear certification activities as defined in AFI 63-125. Within the Sandia Aircraft Compatibility Department, an aircraft is assigned to an electrical engineer and a mechanical engineer (hereafter referred to as the Sandia engineer). SNL is a Prime Contractor for the NNSA and is chartered to ensure the NNSA that a capability exists between US nuclear weapons and the aircraft they are carried on throughout their life in the inventory. The AFNWC and SNL team members that conduct the various aircraft compatibility tests, work together to ensure both the USAF and NNSA that a capability exists between the weapon and the aircraft for all nuclear weapons carried on the aircraft. This responsibility exists for the entire life of both the aircraft and the weapons. The AFNWC and NNSA agreement on division of responsibilities are defined in Memorandum of Understanding (MOU) DE-GM04-2001AL77133. The MOU delineates the responsibilities regarding the design requirements, test requirements, and documentation of AMAC used with aircraft-delivered nuclear weapons (bombs and warheads) developed by the NNSA with overall weapon system requirements established by the DoD. The AFNWC and Sandia Aircraft Compatibility Department works with the various military agencies and aircraft contractors to assure the NNSA that any given aircraft has a capability to successfully monitor, control, and deliver the nuclear weapon(s) it is required to carry. Part of this process involves attending aircraft and weapon Project Officer Groups (POGs), and conducting various mechanical and electrical tests. These meetings and tests are attended by agencies that have some level of responsibility for nuclear certification of the aircraft or weapon. Sandia and the AFNWC work together to coordinate NNSA requirements into the aircraft program so that a capability can be eventually granted and maintained during the life of the aircraft.

3.1. Sandia Aircraft Compatibility works with Sandia's Air Delivered Weapons Systems Engineering Centers throughout the life of the weapon program to assure an electrical and mechanical capability exists on the aircraft. They keep these Centers up to date on changes to the AMAC specifications (System 1 and 2) that defines the aircraft/weapon interface, and on changes to the aircraft's AMAC system and delivery characteristics that might impact the weapon's ability to reliably function. The Weapon Departments within these Centers, in turn, keep the Aircraft Compatibility Department and the AFNWC updated on what changes have occurred, or will occur because of a new development or stockpile improvement on a given weapon system. This is the process by which the ACCDs are kept current.

3.2. The ACCD is a drawing that exists on each nuclear gravity bomb in the inventory that describes in detail the compatible configurations on any given aircraft with that bomb. This includes such things as a list of compatible aircraft, compatible AMAC controllers, allowed mixed weapon load configurations, allowed configurations of Electronic Counter Measure (ECM) pods, delivery limitations, and compatible AMAC software with the bomb. The ACCD exists as long as the bomb is in the inventory and is maintained by the weapon departments at Sandia.

3.3. The ACCD equivalent for the W80 warhead carried on aircraft is the Compatibility Certification (CC) Drawing. The SNL Aircraft Compatibility Department is responsible for the compatibility aspects of the W80 nuclear warhead on Air Launch Cruise Missiles

(ALCMs). Their responsibility in this area, like with nuclear bombs, is to make sure a capability continues to exist as long as the warhead is in the stockpile.

3.4. To help AFNWC staff understand how Sandia Aircraft Compatibility Department works with other Sandia Departments, listed below is a description of the work involved:

3.4.1. **Advanced and Exploratory Systems Departments**. Provides information on current aircraft capabilities for new weapon systems as well as a review of new weapon system designs.

3.4.2. **Military Liaison Department**. Provides training on aircraft AMAC systems to DoD personnel who attend their weapon classes, review Unsatisfactory Reports (URs) that come in from the field on weapon failures that are possibly aircraft related, and provides a review of weapon source data manuals for accuracy in the area of aircraft information.

3.4.3. **Use Control Departments**. Determines aircraft compatibility with new Permissive Action Link (PAL) devices currently in work as well as changes made to the Category D PAL requirements defined in System 1 and 2 aircraft/weapon interface specifications.

3.4.4. **Nuclear Safety Assessment Department**. Works with this Department in the area of new aircraft AMAC designs for Unique Signal Generation (USG) and provides consultation to the Nuclear Weapon System Safety Group (NWSSG).

3.4.4.1. **USG**. USG is the safety device within weapons that requires a specific code pattern generated by the AMAC system in order for prearming of the weapon to occur. How this code is generated and stored in the aircraft is defined in the AMAC Final Design Approval Report (FDAR) and the Nuclear Safety Analysis Report (NSAR).

3.4.4.2. **NWSSG**. The NWSSG is made up of Sandia, NNSA, and DoD personnel that review new and current aircraft/weapon systems to assure a capability exists in accordance with nuclear weapon system safety standards DoD 3150.2.

3.4.5. **Stockpile Evaluation Departments**. The Aircraft Compatibility Department works with the Stockpile Surveillance Departments in the area of support to the Joint Test Assembly (JTA) program. The Aircraft Compatibility staff provides consultation on AMAC designs prior to a JTA drop. If there is a problem after the drop, they help determine if the aircraft could have contributed to the failure.

3.4.5.1. **JTA Program**. The JTA program is an evaluation of the weapons in stockpile to verify they will work reliably during their life in the inventory when delivered from the carried aircraft. A JTA unit is a real nuclear weapon removed from the stockpile, has a telemetry package or in some cases ballast installed in place of the physics package, and is delivered by an aircraft per the requirements defined in the weapon's stockpile-to-target sequence (STS) document.

3.4.6. **Flight Dynamics and Experimental Mechanics Departments**. Determine if weapon parameters are exceeded based upon data received on wind tunnel and weapon separation tests, lug and sway brace loads analysis, and weapon Vibration Flyaround

Assembly (VFA) tests conducted as a part of the mechanical tasks required to release an ACCD.

3.4.7. **Electromagnetic Test and Analysis Department**. Supports analysis of weapon compatibility on aircraft with radiating equipment in the field of the weapon.

3.4.8. **Tonopah Test Range Department**. Provides data reduction and range support when aircraft compatibility testing requires a ground station.

4. Task Description. This section describes the compatibility certification tasks defined in AFI63-125, MIL-STD-1822A, and SAND2011-2981. Each section provides a paraphrased opening section in italics from these documents which define the specific task, followed by a detailed explanation of what is required to accomplish these tasks for an ACCD, CC, and NCCS release.

4.1. **Wind Tunnel Tests.** *Wind tunnel tests are normally performed to obtain (1) store loads data and (2) separation data prior to conducting flight tests. They are also used to validate Computational Fluid Dynamics/store separation software that will be used for the bulk of the store separation analyses with the intent of reducing the required number of drops specified in Section 3.2. The DoD is interested in obtaining data associated with loads imposed on the aircraft by the store while Sandia is mostly interested in information about the loads imposed on the bombs. The ideal way to do this testing is to get involved early in an aircraft development program when the aircraft contractor is conducting wind tunnel testing for conventional stores. At this point the costs are minimal and the facilities and test hardware are available.*

The wind tunnel tests are generally performed in DoD facilities with the DoD paying for tests involving new aircraft and the DOE paying for tests on new bombs or modifications to existing ones. Things to consider during Wind Tunnel Tests are:

4.1.1. **Internal Carriage.** The "Doors Closed" loads environments have been measured but have never been large enough to merit an analysis. The doors-open and doors-opening-and-closing transients are the critical flight conditions that need loads analyses. Sandia aerodynamicists in the past have stated that internal carriage loads data is very difficult to obtain because of scaled-down weapons and weapons bays and the interference of wind tunnel instrumentation hardware. Critical loads, if required, are usually obtained during full-scale development flights (see 4.3. Lug and Sway Brace Loads Analysis). Separation of scaled weapons out of weapons bays can be satisfactorily accomplished. Various photo techniques showing pitch, yaw, and roll at selected ejection velocities are used to provide data.

4.1.2. **External Carriage.** Wind tunnel testing is expensive but ideally suited to provide external carriage loads and separation data early in the aircraft and/or weapon development phase. Various store loading configurations can be tested leaving the "worst case" loadings to be flight tested. Wind tunnel time provides better comparative data than an aircraft flight test because tunnel conditions can be very accurately controlled. Flight test conditions are frequently compromised because Mother Nature and other factors such as test pilots cannot always be counted on to provide precise flight profiles. Wind tunnels have a variety of methods and techniques to obtain loads and separation data. Consulting with Sandia's Flight Dynamics Department to select the one best suited to obtain the data needed, and then coordinate with the using service and the aircraft contractor to join in on their tests. If that is not possible, then if required, Sandia would need to be prepared to fund a Sandia test. Weapon models and wind tunnel data support have been provided by Sandia's Engineering Sciences Center. It is also important to get the Sandia Experimental Mechanics Department involved in your program, so that he or she can use the data provided and produce the required loads analyses on the bombs required in Task 4.3.

4.2. **Weapon Separation Tests and Analysis.** *Weapon separation tests and analysis help assure the safe release of weapons from aircraft throughout the flight envelope desired by the user. The test units are generally Bomb Dummy Units (BDUs) supplied by the DoD but may be weapon development units supplied by SNL. The United States Air Force (USAF) have used in past tests, BDU-38s for B61-3,4,7, and 10 separation testing. Currently there is no equivalent BDU's for B61-11,12, or B83-1 testing. The data acquired in the weapon separation tests is usually in the form of video taken from the release aircraft or from a chase aircraft. The video is generally taken by the military. The military may also perform some computer analysis on the video to determine trajectory, orientation, and other important parameters. This data is used by the military to verify safety, accuracy, and other information. The video and computer-generated data are supplied to Sandia for their analysis. Sandia engineers use this information to verify that the bomb is released from the aircraft with the proper aerodynamic characteristics. In a retarded drop, the weapon must not pitch or yaw beyond certain limits so that the parachute will operate correctly. Tests are also conducted at the extremes of the flight envelope to verify repeatable ballistics for free-fall units or proper decelerations to operate weapon Environmental Sensing Devices.*

4.2.1. It is important to note that a "safe" separation from an aircraft point of view means that the bomb will not hit the aircraft; however, a safe separation from an aircraft viewpoint may not be satisfactory from a weapon standpoint. Examples of this unsatisfactory performance include trajectories that do not allow the weapon to function properly or trajectories that produce excessive side load on the bomb when a parachute is deployed. Thus, it might be a safe separation, but from a weapon standpoint it might not be satisfactory.

4.2.2. Sandia engineers have found that BDU-38s produce poor separation results because they are not good physical representatives of the B61 mods currently in the inventory (wrong weight, center of gravity, and moments of inertia). Future separation testing will use stores that closely matches the WR physical characteristics.

4.2.3. As an example of how things could happen, years ago a B28 test unit was released from the weapons bay of a B-52 and about one bomb length below the aircraft, the bomb had rotated 90 degrees to a nose-down attitude. The velocity-sensing devices were blanked out so arming could not occur. In addition, the marginally unstable bomb continued to tumble producing an unacceptable trajectory - it would never hit a designated target. The contractor who was demonstrating releases off a rotary launcher said it was "safe." Sandia said it was unsatisfactory. After repositioning the bomb on the launcher and by changing the bomb rack ejector forces, subsequent drops were safe and satisfactory.

4.2.4. Another "rule" for satisfactory separations where the parachute is deployed is that the pull angle of the deployed parachute should be less than12 degrees with respect to the bomb centerline, otherwise, parachute shroud lines could be cut or damaged on the bomb tail can or the tail can could be damaged by excessive side loads generated by the off-angle pull of the parachute shroud lines.

4.2.5. The parachute deploy delay times to be used operationally should be demonstrated and used during separation tests. Factors to be considered are: a) to determine that the nose-down pitch angle and the distance below the aircraft are adequate to prevent parachute deployment devices from hitting the aircraft. Be aware of deflected aircraft control surfaces; and b) to be aware that for some low-level retarded releases there could be a release altitude coupled with an ejection velocity where the bomb will hit the ground before the bomb has had a chance to trajectory arm. The options then are to trade off delivery altitudes, ejection velocities, and parachute deploy delay times until the USAF is happy with the solution.

4.2.6. At the beginning of a compatibility program involving a new aircraft to employ a stockpiled bomb, this question is frequently asked of the Sandia engineer: "How many drops do you require?" The answer is usually "four," as follows: One retarded at low-altitude, minimum parachute q; one retarded at low-altitude, maximum aircraft or parachute q; one high-altitude free-fall at close to minimum aircraft q; and one high-altitude free-fall at maximum aircraft q. This answer by the Sandia engineer will usually provide many more than four drops. The aircraft contractor aero and test teams will select their first drop to be at a very benign condition, usually a mid-envelope Mach/altitude test point and then work their way around the flight envelope as flight clearances are provided by the flight safety test teams. If their wind tunnel predictions agree with actual drops, then the tests will follow a logical build-up program.

4.3. **Lug and Sway Brace Loads Analysis.** *The purpose of the lug and sway brace analysis program is to determine the mechanical loads imposed on weapon lugs and on the weapon case where the lugs attach and where the bomb rack sway braces make contact during carriage. The loads are determined for the full flight envelope of the aircraft. The flight envelope is a definition of mach number or speed versus altitude requirements for the aircraft. The bombs were designed to a set of requirements based on aircraft called out in the original Military Characteristics (MCs) and this analysis verifies that the aircraft being added to the requirements does not impose higher loads on the lugs and on the weapon case. Although it is possible to directly measure these loads by using instrumented bomb test units, this has been found to be prohibitively expensive. Other means of producing the required data have been developed. Bomb case loads for external carriage are generally predicted based on the aerodynamic characteristics that have been measured in wind tunnel tests and the performance characteristics of the aircraft. The aircraft performance characteristics are generally available from the aircraft development agency.*

4.3.1. Sandia uses the LUGSAN software to compute the lug and sway brace loads resulting from various aircraft maneuvers. This software program requires data that defines the maximum performance capability of the aircraft, the associated bomb aerodynamic drag coefficients, geometric data about the store-aircraft interface, and the location of the cg of the store with respect to the cg of the aircraft. This data is obtained from wind tunnel tests, MICDs, and liaison with the aircraft contractor, etc.

4.3.2. The lug and sway brace loads analysis in an aircraft/bomb compatibility program is required before starting the Vibration Fly-Around (VFA) tests. This analysis can be tailored to the approximate flight profile required by the test and the analysis is used to satisfy the services safety of flight requirements. A final loads analysis is required before the capability is added to the ACCD, and if the analysis indicates limitations exist, those limitations are to be stated in the ACCD notes.

4.3.3. As an example of gathering loads data on an aircraft, the B-2 aircraft compatibility program took a different approach to store loads. Northrop looked at aircraft geometric data, ejector rack sway brace torque, g-loadings on the aircraft, and other factors and came up with a preliminary loads analysis. Sandia studied the data and determined that the combined loads were below the strength capabilities of the B61 and B83, and determined that it was okay to fly the scheduled vibration flyarounds. Following this analysis, the B-2 Combined Test Force was tasked to record loads data from instrumented B61 and B83 dummy shapes during some of their doors-open carriage demonstrations. The next step was to integrate the measured flight loads into the preliminary loads analysis, and produce a final loads analysis report. Sandia requested a flight test with a bomb in the 3 or 9 o'clock position on the rotary launcher, with lug and sway brace instrumentation, and then eject the bomb that would be in the 6 o'clock position. The high ejector velocities required on this aircraft, result in high compression loads on the lower sway brace pads and high loads in tension on the bomb lugs of those bombs in the 3 or 9 o'clock position. So depending upon the stores loading on an aircraft, may require consideration of loads data on adjacent stations while another store is being released.

4.4. **Vibration Fly-Around Tests and Analysis.** *The purpose of the Vibration Fly-Around (VFA) tests and analyses is to determine the vibration environment imposed on components inside the bombs when carried on the aircraft of concern. The aircraft with the VFA test unit loaded in configurations of concern, is flown at various aircraft maneuvers of interest (cruise, maximum velocity, throttle chop, windup turns, etc.) mach number-altitude points within the desired flight envelope that by analysis have been determined to provide the worst-case vibration environments to the weapon. The vibration and temperature environments are recorded by the VFA test unit. The vibration spectra obtained from this flight testing must be lower than the spectra for which the components were originally designed in order for the aircraft to be judged as compatible with a particular bomb. In some cases, certain flight restrictions are placed on special configurations that don't pass the tests at all points within the flight envelope. The aircraft in some tests are configured in what are considered to be worst-case configurations, and other less severe configurations may be cleared by analysis. The VFA test units are supplied by Sandia. Currently, Sandia has four VFA test units: a B61-3 VFA, a B61-7 VFA, a B61-11 VFA, and a B83 VFA. The test units use a newly developed SE3370 onboard recorder, VIPER2 (Vibration Performance Recorder, Second Generation), to acquire vibration, shock, acoustic, and temperature data. The data is read out via a laptop computer that can perform Fast Fourier Transform data processing giving PSD plots. VIPER2 is capable of in-flight recording to nonvolatile memory of vibration/shock events on 32 independently programmable vibration/shock channels. VIPER2 can also record 24 independently programmable periodic temperature measurements, 8 thermocouple, and 16 thermistor channels. The vibration memory of 2 GBs of storage is enough for a continuous sampling of all 32 channels at 30 K samples/sec for 1070 seconds. The temperature memory* *is a single 256 MB SD nonvolatile memory module with the capacity to store 38 days of temperature data on all 24 temperature channels at 1sec/sample. A W80 Vibration-Acoustic Test Unit (VATU) is also available from Sandia. The VATU is a mass mockup assembly based on a modified W80-1 Type 3 case with a WR Weapon Electrical System (WES). The VATU can also be used for static ejection testing. The VFA test units duplicate the WR mass properties and will have the real components or mass mockups of the components of concern installed. The components of concern are instrumented with accelerometers and/or temperature sensors. The aircraft are supplied and operated by the military and the tests are staged out of a military test base and flown over a DoD, DOE, or NATO test range.*

4.4.1. One of the problems with this task is getting the flight test data. Bombs are carried externally or internally and the aircraft can be either operational or an early production model. Thermal tests using VFA test units, would include ground and flight data to support the capability of the bomb to be compatible with MC and STS temperatures. For external carriage, compatibility analyses can be accomplished if the mach/altitude and time at those conditions can be provided. For internal carriage, the aircraft contractor should provide temperature profiles experienced during ground and flight operations. A good place to start is to obtain and look at the temperature design requirements used for aircraft equipment installed in the weapons bay and/or pylon station. The next step is to have the aircraft contractor provide temperature profiles based on their instrumented units during flight tests. If required, an instrumented unit could be provide by Sandia. For flight data acquisition, the techniques used for the VFA tests are appropriate.

4.4.2. Here are three examples of how VFA data was acquired in the past:

4.4.2.1. **PA-200**. Sandia could not use T/M frequencies in Germany because of interference with their TV channels so they started planning at least a year ahead of the test with a designated test aircraft, found extra tracks on an existing on-board tape recorder, added co-axial wiring between an external fuselage bomb station and the recorder, and added on-off 28 Volt DC control wiring plus switches in the cockpit. Sandia range support personnel shipped over a checkout and data playback trailer along with a diesel engine driven 120 Volt AC-60Hz generator. Prior to flight Sandia ran a few minutes of tape and played it back in the trailer to check on correct operation of all channels. After the flight, the stripped-out tape tracks were reviewed and if the data was "good" a duplicate was made and at the end of all the tests, the tapes were hand carried back to Sandia for data reduction.

4.4.2.2. **F-16 with LANTIRN**. In 1990 the USAF added LANTIRN to the F-16 aircraft, which required that additional testing be performed to evaluate the change in boundary airflow around the bomb caused by the addition of these new external pods on the forward fuselage of the Block 40/42 F-16C, D aircraft. The USAF made a just-off-the-line production aircraft available for these tests and would not allow any changes or additions to this combat-ready aircraft. In this case, we used the aircraft integrated AMAC system and the bomb CF2438 pullout cable to control the air-to-ground T/M system. The VFA test unit had a small antenna mounted on the bottom of the afterbody to get the signal to an Sandia ground station for checkout or to a tracking radar dish at Vandenberg AFB, CA, which was linked to a ground station during the flights. The Vandenberg ground station was manned by Sandia personnel who made duplicates of the data flight tapes plus they worked with a data-reduction program, which has the capability of directly computing Power Spectral Densities (PSDs). The F-16C was configured without external fuel tanks, which required tanker support, thus allowing all the high-speed data runs for one bomb configuration to be completed on one flight.

4.4.2.3. **B-2A Internal Carriage on Rotary Launchers**. Flight testing began in the spring of 1994 at Edwards AFB. Air vehicle No. 2 (A/V-2) had been selected to accomplish this task and a dedicated tape recorder was installed in the aft equipment bay. A/V-2 had no requirement for AMAC software in the system to control a nuclear bomb; thus, a 28-Volt DC on-off control switch was installed in the right pilot's station plus hard wiring to a bomb location on the rotary launcher. There was also an indicator in the cockpit that showed the amount of recorder tape available in seconds. The plan was to load the VFA unit on the launcher in the Integrated Maintenance Facility (IMF), check the wiring in the launcher, check the wiring in the aircraft, load the loaded launcher in the aircraft, and check the system by running a few minutes of tape and playing it back in a Sandia-provided ground station trailer. This same ground station was used to do on-site data reduction on the data tapes received after each flight. Sandia compared the data from the flight with the capabilities of the bomb and bomb components.

4.5. **Static Ejection Tests.** *Static ejection tests are conducted whenever questions arise about the velocity, acceleration, pitch, shock, and vibration environment that will be imposed on special weapon components during ejection. A newly designed or modified rack will generally require testing. Sometimes the military will want to change the electronically fired impulse cartridges that eject the weapon. If they do, the new cartridges will probably have to be tested to confirm that shock and vibration limits of the bomb's components are not exceeded. Static ejection tests can also be used to help determine the bomb pitch and ejection velocity that will occur during weapon release. The test configuration generally consists of a DoD-supplied rack mounted on a relatively rigid beam with either a VFA/VIPER2 configuration loaded on the rack or the W80 VATU loaded in a cruise missile that is loaded on the rack. The unit is ejected off the rack and the acceleration data spectra is recorded. A video of the test is usually recorded using a high speed camera to record pitch angle and velocity information. The tests may be run at a military contractor facility or at a military engineering facility. These tests have also been run with the rack mounted on a real aircraft in order to get real-world (less severe) results.*

4.5.1. The text above suggests that these tests are run when the military wants to change cartridges. The net result in a cartridge change will only change the force applied by the ejector pistons to the outside bomb case. On ejector racks with dual pistons there is usually a mechanical device in the cartridge gas plumbing system that will allow some throttling of the gas to a forward or aft piston, thus allowing the test agency to change the pitch of the bomb at release. Prior to the first nuclear bomb release from a new aircraft, the static bomb pitch should duplicate the bomb pitch and ejection velocity recorded during wind tunnel tests.

4.5.2. For example, the rack orifices on the MAU-12C/A rack on a USAF aircraft for internal carriage were changed part way through the flight testing to accomplish a smaller nose-down pitch at higher q conditions.

4.5.3. An interesting problem always shows up when one attempts to do a series of static ejection tests: what to use on the ground or in the pit or wherever to absorb the shock of the test unit being ejected. If the shock-absorbing material is too soft, it bottoms out; if it is too springy, it could bounce back up and hit the rack; if it is too hard, the case and/or tail, nose, or other structure could be damaged by repeated ejections. Sandia archive file "CSRL/SRAM Ejection Tests" for pictures and sketches of a cardboard box technique for capturing the SRAM as it was repeatedly ejected at Scot Incorporated, and at Boeing, Wichita. Sandia archive file "B-1 Static Ejection Tests" also shows a slightly different method for capturing bombs during ejection tests. These two files will also show some instrumentation techniques for gathering pitch and velocity data. High-speed video cameras could also simplify the documentation of the events.

4.6. **Develop Mechanical Interface Control Drawing (MICD).** *The MICD depicts the physical configuration of an aircraft loaded with bombs. The drawings are generally produced by a military contractor or by the military. The MICD is normally signed by the originator, by the military system program office, by the appropriate military weapons integration organization, and by Sandia. The signatures are an indication that the drawing is complete and that it fully depicts the aircraft and the installation of nuclear bombs. The signatures indicate that the signatories agree that no one will make changes to the MICD without informing the others. Revisions to the MICD shall be submitted to the applicable service agency for review and approval. The revised MICD must be approved by all signatories before it is accepted by the appropriate System Program Office (SPO). The MICD consists of at least the following:*

Signature block for responsible agency representatives

The aircraft external configuration

The aircraft pylons with bombs installed

The aircraft weapons bay with bombs installed

Ejector rack, pullout cables, and other details

References to drawings to include the aircraft, the ejector rack, the appropriate bombs, and other items such as ECM pods, fuel tanks, and missiles.

4.6.1. The MICD is one of the documents that will be used and maintained throughout the life of the aircraft/bomb system. For a specific aircraft, there should be a separate drawing for each bomb required on that aircraft so that if a bomb is deleted or added, then that MICD is deleted or a new one added and the documentation will track the capability.

4.6.2. Typically the first sheet should list aircraft version/configuration/equipment and contain all the notes and references, a signature block, and if possible, a 3-view of the aircraft. The next sheet should show "big picture" views of pylons, launchers, etc., and then follow-on sheets should show smaller views with additional details. The notes should include the parachute and spin rocket deployment time selected for this application, the cartridge and orifice callouts, and the required pullout cable for each bomb mod.

4.6.3. The MICD must be completed before the mechanical fit tests so the drawing can be checked for accuracy.

4.7. **Mechanical Fit Tests.** *Mechanical fit tests are performed to verify the information given in the MICDs. Sandia-supplied CTUs are loaded on operational aircraft and measurements are made of spacings and dimensions that are critical to bomb/aircraft compatibility. These dimensions are compared with those given in the MICDs. The measurements are often made on several aircraft to get a measure of variability. The mechanical fit tests are usually performed at the same time as the five-aircraft AMAC electrical interface tests although preliminary fit tests may be performed earlier to uncover incompatibilities in time for them to be corrected before the final test.*

4.7.1. The task of doing the fit checks to verify the accuracy of the drawings can be completed using CTUs and the best available aircraft hardware. Although the support and/or loading equipment are not part of the MICDs, it is necessary to observe where and how this equipment comes in contact with the bombs and report any concerns to the users.

4.7.2. Often it is useful to take an early draft of the drawings to the field and "piggy-back" on some other activity in order to determine voids or incomplete data. However, before drawings are signed off, a full-scale fit-check has to be accomplished. For internal carry, doors open for release and doors-closed clearances must be verified. Landing gear retractions are sometimes required to validate clearances on external carriage, along with speed brakes, ailerons, and/or flaps.

4.7.3. Taking still photos or video of the mechanical fit is a good way of documenting the test for future reference.

4.7.4. The agencies that will sign the MICD should be invited and should be present at the final fit test event.

4.8. **Develop Preliminary Design Report (PDR), Final Design Approval Report (FDAR), and FDAR Analysis.** *To document the AMAC design, the System 1 and 2 specifications require that the AMAC designer submit to their aircraft System Program Office a Preliminary Design Report (PDR) and a Final Design Approval Report (FDAR). These reports are then submitted the AFNWC who then provide a copy to Sandia. The AFNWC and Sandia agencies then review the documents and provide recommended changes and eventual approval of the documents back to the aircraft SPO. In the early stages of a new aircraft design, a Preliminary Design Report (PDR) will be produced and reviewed in order to aid the designer in producing a usable AMAC design. The FDAR is a basic document that is required by both System 1 and 2 Aircraft Monitor And Control (AMAC) specifications, and is the document which the AMAC designer uses to demonstrate that the design of the AMAC system will in fact meet the requirements of the AMAC specification. It contains an electrical analysis of the entire AMAC system circuitry, including power supply characteristics, switching logic, monitor circuitry logic, individual component characteristics and digital or analog control logic. In the case of an aircraft with an integrated AMAC such as the F-16 or the B-2, it also contains a description of the software used to control the weapon interface. An FDAR generally shows a comparison of conservative design results obtained from analysis versus AMAC specification requirements. The FDAR accompanies the Electrical Interface Control Drawing (EICD) as a supporting* *document. The FDAR is usually prepared by the designer of the AMAC system, which usually is an aircraft contractor or a military engineering laboratory. The completed FDAR is reviewed by SNL and by the AFNWC. It is formally approved and signed off by SNL and the AFNWC. The signatures indicate that the signatories agree that none will make changes to the FDAR without informing the others. Approval of the FDAR precedes the five-aircraft electrical test. The production of a useful FDAR requires a significant amount of give and take between the AMAC designers (generally a DoD contractor) and the end users of the document, who are the military nuclear weapons organizations and Sandia. The System 2 digital AMAC specification, is defined by the AMAC POG System 2 Specification Standard. It exists between the nuclear weapon and a single MIL-STD-1760 umbilical cable. The specification defines message format requirements needed to provide monitor and control of a nuclear weapon for the serial digital data interface, the electrical power provisions, the address line requirements, and the multiplex data format between a nuclear weapon and a carrier aircraft. All stated requirements are mandatory for the carriage and operation of a nuclear weapon. The requirements are in addition to requirements levied by MIL-STD-1760 and MIL-STD-1553, and supersede the Military Standards where conflicts of requirements appear. It is the intent of the System 2 specification to use MIL-STD-1760 requirements and define only those additional requirements needed for nuclear weapon compatibility. The System 2 specification has the same requirements for design approval documentation as System 1. The FDAR is reviewed by the AFNWC and by Sandia National Laboratories (Aircraft Compatibility Department) for completeness and accuracy to determine whether or not the aircraft meets the appropriate interface specification. The FDAR is formally approved by SNL and the AFNWC. The FDAR and EICD are the prime source documents used in the preparation of a test plan for the five-aircraft AMAC tests discussed below. The analyses in the FDAR for interface voltage levels are worst case; thus, it is expected that actual measurements will yield less severe results. The EICD is also used in test planning because it contains information about how the aircraft AMAC works.*

4.8.1. The AMAC specifications define the requirements that the aircraft and nuclear bomb must meet. There have been several different types of AMAC specifications used on many different aircraft over the years. These specifications covered AMAC designs ranging from simple dedicated hardwired controllers with limited capability to the complex software and hardware integrated systems used today. In the past Sandia published all AMAC specifications. Today the responsibility for publication of AMAC specifications rests with the AFNWC. Currently, there is only one AMAC specification, System 1, used on all the aircraft listed in the ACCDs. The System 1 specification has gone through many iterations over the years and the last version published by Sandia was known as Sandia Drawing No. 185475 issue W. The current System 1 specification is AFNWC Specification Standard No. SYS 1001-02. A Handbook for issue W of the System 1 specification was published by Sandia (SAND97-3147) and can be used for the SYS 1001-02 version. The Handbook explains how to properly interpret the System 1 specification and is a good reference for both the aircraft and bomb sides of the interface. The System 1 specification, along with the System 2 Specification Standard No. SYS 2001-04 for future digital AMAC interfaces, are updated by NNSA, DoD, and Sandia representatives, who are members of the AMAC Project Officers Group (POG). All recommended changes to these specifications have to be approved by the POG prior to a new issue release.

4.8.2. The PDR describes in as much detail as possible, the AMAC hardware and software design. The PDR is submitted early enough in the aircraft program so that any necessary design changes can be implemented without impacting the program's schedule, usually in the Engineering & Manufacturing Development Phase. The FDAR describes in detail all aspects of the AMAC system. It is used to assure SNL, NNSA, and the AFNWC that the aircraft is capable of meeting the requirements specified in the System 1 and 2 specifications for properly operating the nuclear bombs it will carry. The FDAR must cover all aspects of the AMAC design since this document will be used throughout the life of the aircraft. It should not be approved until all required information, as specified in the AMAC specification, are included. Sometimes it is difficult to get information added to an FDAR, because funds may not be available from the government's System Program Office (SPO) to pay the AMAC designer to include information that was not asked for in the original contract. Once the FDAR is approved, a requirement in the System 1 and 2 specification states that the FDAR must be kept updated so that it represents what is currently in the inventory. Information is added to the FDAR whenever changes are made to the AMAC hardware or software. Funding for this kind of update is provided by the war fighter commands through the aircraft's SPO. The FDAR must be submitted for approval a minimum of 60 days before the five aircraft AMAC test is conducted.

4.8.3. The AMAC Design Approval Procedures defined in the System 1 and 2 specifications, states the requirements for the kind of information that must be included in an FDAR. The System 1 specification outlines the information required in the same paragraph format as the Aircraft Interface Requirements (Section 3.2 of the System 1 specification). This allows the AMAC designer to relate the requirements of the FDAR to the applicable requirements of the interface design. Occasionally the AMAC designer misinterprets the specification requirements and does not include all of the analysis required. For example, the System 1 loads represent the worst-case condition. The FDAR analysis of these loads on each pin is to be calculated at the worst-case temperature, typically the highest temperature to which the AMAC system can be exposed. Sometimes the designer only calculates at ambient temperature. A detailed explanation of what to look for in the review of an FDAR can be found in the System 1 Handbook.

4.9. **Develop Electrical Interface Control Drawing (EICD).** *The EICD is a signature-controlled drawing set detailing the aircraft/nuclear interface and associated electrical systems. The FDAR is part of the EICD, and like the FDAR, the EICD must contain information extracted from contractor documentation in order to complete a composite drawing reflecting the basic electrical interface features. It is required that the EICD be provided to the AFNWC and SNL in the same time frame as the FDAR. Revisions to the EICD shall be submitted to the AFNWC and SNL for review and approval. The signatures indicate that the signatories agree that none will make changes to the EICD without informing the others. The revised EICD must be approved by all signatories before it is accepted by the appropriate SPO. The items listed below are included in the EICD. Release system information is to be included as required by the using agency.*

The EICD consists of at least the following:

Signature block for responsible agency representatives

System block diagram of the aircraft AMAC and release electrical systems

Aircraft AMAC system schematic

Aircraft release system schematic

Aircraft AMAC and release component descriptions

Aircraft AMAC and release power source descriptions

List of nuclear weapons to be used on AMAC interface

List of ancillary test equipment to be used on AMAC interface

List of training devices to be used on AMAC interface

List of drawings that define the nuclear weapons, ancillary test equipment, and training devices appropriate to the aircraft

FDAR.

4.9.1. The Electrical Interface Control Drawing (EICD) (also known as a Weapon System Electrical Compatibility Control Drawing on the B-52 and Electrical System Description Drawing on the B-2) is a very important and useful document. It is used as a requirement for releasing an ACCD, as a way of understanding how the AMAC and release system works, as a tool for troubleshooting when problems in the field occur, and as an aid in the design of future weapon systems. It is the only electrical drawing comprised of all the aircraft designer's drawings used for building the complete aircraft system. Without this single drawing package, an enormous amount of documentation would have to be researched to piece the AMAC and release systems together as it exists from the aircraft engine power source to these interfaces. The EICD is structured this way to show the reader how the system flows (from left to right in a logical manner) and all the components in the aircraft that make up the power source, AMAC, and release systems.

4.9.2. The requirements of the EICD are defined in the AMAC Design Approval Procedures Section of the System 1 and 2 specifications. The FDAR is included in the EICD package because it contains all of the analysis necessary to prove whether or not the AMAC system meets the AMAC specification. A list of all the other equipment (besides nuclear weapons) that could be connected to the AMAC and release systems is also included. Defining what will be connected to these systems establishes what equipment will be used throughout the life of the aircraft.

4.9.3. The EICD is signed off by all agencies involved in the certification of the aircraft/bomb system. This signoff indicates that everyone approves the design and agrees on the accuracy of the package's contents. The EICD, like the Mechanical Interface Control Drawing (MICD), is updated throughout the life of the aircraft. Sometimes it is difficult to get information added to a signed off EICD or MICD because funds may not be available from the government to update the drawings. Signoff will occur every time there is a change to these drawings so that they will represent the current configuration of the AMAC and aircraft release systems. The Electrical System Description Drawing on the B-2 is an excellent example of what an EICD package should look like. When the AFNWC and SNL engineers, and the aircraft designer are developing an EICD, it would be worthwhile for them to review this drawing package, and for the AFNWC engineer to provide a copy of the B-2 ESDD to the aircraft designer for reference. This will make the engineer's review of the EICD much easier when it is time to approve the drawing.

NOTE: Tasks 4.10 and 4.11 will be covered together because their content is almost identical.

4.10. **Preliminary Weapon/Aircraft Electrical Interface Tests.** *Preliminary aircraft/weapon electrical interface tests are not a requirement for the release of an ACCD, but they are generally conducted as part of a nuclear certification program for a new aircraft or for an aircraft undergoing significant modifications. The purpose of these tests is to verify that the design is on a path to meeting the requirements to properly operate nuclear weapons. The tests also give test personnel a chance to refine the test plan for the five-aircraft AMAC tests. Given that the five-aircraft AMAC tests can result in a very expensive retrofit if the aircraft fails the tests, it is a good engineering practice to conduct preliminary tests on the aircraft AMAC system before the five-aircraft AMAC tests. The five-aircraft AMAC tests, described in the next section, are run for the purpose of verifying that operational aircraft actually meet their requirements so that they can be added to the appropriate ACCDs. These tests are done on operational aircraft already in the field and it is expected that they will pass these tests. If they do not, it may mean that a retrofit needs to be performed on the aircraft. Also, a retrofit will probably result in a delay in the initial nuclear weapon operating capability for the aircraft since the five-aircraft AMAC test typically occurs late in a nuclear certification program. Hence, it is a good engineering practice to test the aircraft AMAC system before the five-aircraft AMAC test.*

The preliminary AMAC tests may use laboratory hardware before full aircraft hardware is available or they may be conducted on test aircraft that are being used to evaluate the new design, or both. They can be performed at a contractor's facility in the case of lab tests, or at a military facility that has the appropriate aircraft available. AFNWC and SNL will run the test with its AMAC test equipment, and the results are shared with the engineering community that has responsibility for the design of the aircraft nuclear system.

4.11. **Weapon/Aircraft Interface and AMAC Electrical Tests.** *The purpose of the AMAC electrical interface testing is to ascertain compliance of the aircraft AMAC system with the required AMAC specification and to establish that the aircraft is indeed electrically and functionally compatible with the required set of nuclear weapons. The electrical interface tests are typically some of the last tests to be performed in an AMAC certification program. The tests are normally run on five production aircraft that have been prepared according to military Technical Orders (TOs) for the loading of nuclear weapons. The number five was chosen, based on experience, to be large enough to detect variability between aircraft yet small enough to make the test program tractable. The test programs are performed jointly by AFNWC and SNL. Once certification is granted, additional surveillance tests are conducted periodically by the AFNWC to ascertain whether or not any degradation is occurring to the aircraft system due to aging. The purpose of AMAC surveillance testing for each weapon system is to monitor changes in the baseline for each system that would indicate a design issue created by aging, aircraft modification, or a combination thereof. The required sample size for each weapon system meets a statistical confidence of 90 percent probability that a defect which appears in no more than 10 percent of the interfaces will be detected over a 2-*

year period. A hyper-geometric mathematical-probability model is used based on the number of stations in the fleet that are available to a specific weapon system. The AMAC electrical testing is divided into two parts: ground and air. The ground tests are, in turn, divided into AMAC specification compliance tests and aircraft/bomb electrical function tests. The air tests consist of only aircraft/bomb compatibility tests. The AMAC specification compliance tests, done on aircraft on the ground, check the ability of the AMAC system to provide the electrical interface required by the appropriate AMAC specification. The electrical loads required by the specification are applied to the interface, and the resulting interface voltages are measured. The PAL, USG, and CD (if capable) signals are evaluated for load-handling capability and for the proper number of pulses for timing, pulse amplitudes, rise and fall times, and noise. The aircraft/bomb electrical function tests, also performed on aircraft on the ground, are used to evaluate the ability of the aircraft AMAC system to properly prearm and safe nuclear bombs. Compatibility Test Units (CTUs), which are virtually identical to WR bombs (except for a dummy warhead), are connected to the aircraft AMAC through an electrical breakout box that allows for the measurement of the voltages and currents on all lines used to monitor and control the nuclear bomb. The interface measurement instrumentation also has the capability to monitor transients and noise. The aircraft AMAC system is then used to prearm and safe the CTU (including PAL, USG, and CD operations when applicable). The electrical signals transmitted between the aircraft and the bombs are recorded. The ground tests described above are usually done on five aircraft. For the AMAC specification compliance tests, the aircraft engines are running and the AMAC system is powered by aircraft power since interface voltage levels under load are critical. For the aircraft/bomb electrical interface functional tests, the AMAC may be powered by either aircraft power or by auxiliary power carts, since functionality and sequencing are the important parameters. Aircraft/bomb compatibility tests are also run on aircraft in flight. A SNL battery-powered data acquisition system (known as SE3331) is installed in a specially designed CTU is used to record electrical signals transmitted between the aircraft and the bomb. The data is downloaded and analyzed on the ground after the flight is completed. One in-flight aircraft/bomb interface test is done for each bomb type to be evaluated.

4.11.1. There are three types of System 1 AMAC Testers available to conduct tests at the AMAC interface; SWIFT, SE3312, and SE3331. System 2 testers are currently in design and development to meet future Digital Interface needs.

4.11.1.1. **SWIFT Tester.** The AFNWC Special Weapons Interface Tester (SWIFT) is for verifying AMAC specification compliance. SWIFT is a portable tester used to verify that the aircraft interface meets the AMAC specification requirements. The tests, and the analysis of the data generated by the tests, are performed to support the AFNWC nuclear certification and AMAC surveillance programs. The tester is used to meet the requirements specified in AMAC POG Specification Standard No. SYS 1300, System 1 Aircraft Monitor and Control Test Requirements, testing the parameters defined in AMAC POG Specification Standard No. SYS 1001, System 1 Basic Interface Specification. The tester is used in compliance with 498 NSW OI 99-01, Aircraft Monitor and Control (AMAC) Testing. The SWIFT has been nuclear certified and is included in the Master Nuclear Certification List (MNCL).The SWIFT tester is capable of applying electrical loads per the AMAC System 1 specification on a total of five stations. The number five was established because it represented the maximum number of nuclear bomb stations that can be prearmed simultaneously on any given aircraft in the inventory.

4.11.1.2. **SE3312 Tester.** The SNL SE3312 tester is used to measure electrical data at an aircraft-to-bomb or a missile-to warhead electrical interface during ground electrical function testing. The SE3312 tester is placed in series with the System 1 connector and the weapon umbilical. The tester monitors 27 discrete signal lines and records electrical event data. The tester records voltages, currents, timing, transient voltages and transient currents and sends them to a laptop computer. The tester can also be commanded to record a digitized waveform on any four of the System 1 pins. In this configuration SNL test engineers can capture PAL, CD, USG, SAFE and PREARM waveforms using a two-channel digital scope. It accomplishes this by interfacing between the aircraft and War Reserve (WR) equivalent nuclear weapons known as Compatibility Test Units (CTUs) and Prearm Load Simulators (PLSs). Currently, the SE 3312 is a backup to the SE3331 Tester.

4.11.1.3. **SE3331 Tester.** The SNL SE3331 tester is an event-driven data system that was designed to record the electrical events occurring on the System 1 electrical interface between the CTU and the aircraft during captive carry flight tests. An event is a voltage or current value crossing a defined threshold. The SE3331 is canister-shaped and resides in the parachute enclosure of the CTU. It is battery-powered and has enough memory and battery life to be flown for several hours, and can monitor 27 discrete signal lines at the System 1 interface. When an event is detected on this interface, voltage, current, time, and noise measurements are made and stored in nonvolatile memory. After a flight test is complete, data is transferred to a laptop computer for storage and analysis. A suitcase version of the SE3331 makes it possible to evaluate the functionality of aircraft and bomb at the System 1 interface during ground testing. It is preferable over the SE3312 because of its much smaller size and newer electronics.

4.11.2. CTUs and PLSs were built specifically for Sandia's Aircraft Compatibility Department for AMAC testing purposes. There are five types of CTUs and one type of PLS.

4.11.2.1. **CTU-1**. A CTU-1 is a classified flight-certified unit that is electrically and mechanically equal to a real nuclear weapon except it does not have the physics package. It uses ballast in place of the physics package so that it will represent the same weight and center of gravity (cg).

4.11.2.2. **CTU-2.** A CTU-2 is identical to a CTU-1 except it is unclassified. It is used in test situations that cannot accommodate classified material.

4.11.2.3. **CTU-3.** A CTU-3 is classified like a CTU-1, but it does not have a nose or tail assembly and is not flight-certified. It is used in situations where space is at a premium, like in a lab environment, but where classified material is not a problem.

4.11.2.4. **CTU-4.** A CTU-4 is an unclassified suitcase version of a CTU-2. It is used where portability is the key factor and is not flight-certified.

4.11.2.5. Both the CTU-1 and CTU-2 can have their parachute assemblies removed from the tail assembly and replaced with the flyaround version of the SE3331.

4.11.2.6. **W80-0 CTU.** There are two versions of the W80-0 CTUs used for ALCM testing: classified and unclassified. The classified version contains a W80-0 firing set that does not contain explosives or hazardous material. It contains all of the WR electrical safety and use control components and is housed in a suitcase. The W80-0 unclassified unit is also housed in a suitcase. It contains the safety component but the PAL and CD loads are simulated.

4.11.2.7. **PLS.** A W80 Prearm Load Simulator (PLS) is unclassified and is used in place of a W80 warhead on ALCMs or SLCMs to simulate the electrical interface portion of the warhead. Its small size (2 * 6 in) allows it to be used with USAF training/ferry payloads when flight testing is required.

4.11.3. The AMAC designer should always thoroughly test the AMAC design at the AMAC interface using the loads specified in the System 1 or 2 specifications. The SNL Aircraft Compatibility Department CTUs and PLSs can be loaned for a short period of time so that the AMAC designer can use WR-equivalent hardware in their functionality tests.

4.11.4. A preliminary AMAC test on an aircraft should be highly encouraged and should be performed as early in the program as possible. Preliminary aircraft/weapon electrical interface tests are conducted after a Preliminary Design Report (PDR) is submitted to the AFNWC and Sandia. A preliminary test on an aircraft provides a much better representation of the final five aircraft AMAC tests, than a test on some collection of aircraft hardware in a laboratory. A preliminary AMAC test on an aircraft also helps the AFNWC and SNL engineer's mechanical counterpart conduct preliminary mechanical fit tests using CTU-1's or -2's mounted on the aircraft.

4.11.5. If the preliminary AMAC test is conducted on an aircraft, the test plan should be written the same way as the plan to test the first of five aircraft during the final AMAC test. This will help determine if the final plan is adequate, and it will also provide data for comparison. Typically, the AMAC designer will ask the AFNWC and Sandia engineers to write the test plan because they are the most familiar with what needs to be included in the test.

4.11.6. The preliminary (one aircraft) and the final (five aircraft) AMAC tests are very time consuming because it will probably be the first time everyone involved in such a test on the aircraft is present. A maximum of one week for the preliminary test and one month for the five aircraft tests should be planned. These timeframes take into consideration testing a multiple station aircraft for the SWIFT tests, a number of different multiple station weapon configurations for the SE3331 ground tests, and multiple station SE3331 flight tests There also needs to be a statement in your test plans that no other maintenance or test operations will be allowed on the aircraft while the test is being conducted. This will assure that the engineer will not be preempted at any time.

4.11.7. When a Ground Test Plan is written for an aircraft test, there are three items that need to be considered in the planning stages.

4.11.7.1. **SWIFT and SE3331 Test Programs**. Currently, there is a SWIFT and an SE3331 test program for each of the aircraft in the inventory capable of carrying a nuclear weapon. These programs contain the step-by-step procedures unique to the cockpit switchology of each AMAC system. The SNL Aircraft Compatibility Department has the capability to change the SE3312 programs in order to take into consideration new testing configurations in the future. For instance, one SE3331 test measures the aircraft/bomb interface signals when the System 1 pullout cable is disconnected to simulate release of a prearmed weapon. Pulling the pullout cable and reconnecting only the aircraft side of the cable is a good test to verify that no sneak circuits exist in the AMAC design that would preclude follow-on weapon operations on multiple station aircraft.

4.11.7.2. **AC and DC Load Banks**. Sometimes an AC or DC load bank is required during the AMAC tests. The way the aircraft's power source to the AMAC interface is designed will determine if an AC, DC, or perhaps no load bank is needed. This is done to load down the aircraft's power supply so that it represents the kind of loading that is either present during a nuclear delivery mission, or a load that represents the maximum capability that could be added to the aircraft's power source.

4.11.7.2.1. The aircraft designer is required to analyze the worst-case and nuclear weapon delivery load conditions in the FDAR; this established value is used as a setting for the load bank(s). The AMAC designer can provide the AFNWC and Sandia engineers with these load conditions early enough in the program so that the engineers can use this information for both the preliminary and final AMAC tests.

4.11.7.2.2. Typically, the load bank used for both the SWIFT and SE3312 tests is with aircraft engine power, not with a ground Auxiliary Power Unit (APU). Typically, a ground APU cannot handle the added load from the load bank(s), which will result in the aircraft not meeting System 1 voltage requirements. There may be aircraft that have an onboard APU capable of handling the added load. In these cases, turning on one or more engines are not necessary to conduct SWIFT or SE3312 tests. An APU source of power is acceptable if a change in the aircraft's AMAC software is the only test being conducted. Typically, this is done in follow-on AMAC tests after the five aircraft AMAC tests have been completed. There may be aircraft (i.e., the PA-200 Tornado) that have such stable power supplies even at maximum loading that no problem exists meeting the requirements of the System 1 specification. With this type of aircraft, a load bank may not be necessary in follow-on AMAC tests.

4.11.7.3. **Simulated Flight Test.** Since the USAF are responsible for assuring the release system is working properly, they may ask the Sandia Aircraft Compatibility Department to conduct a simulated flight test on the ground to verify everything works properly when any type of release command is generated. A release command can be generated manually or automatically, and in the case of an emergency, by ground or air jettison commands. Running engines may be required when simulating flight on the ground to gather data not possible in the air. For example, because CTUs are not released (i.e., drop tested) from the aircraft, what occurs at the AMAC interface when an air jettison command is generated would need to be measured.

4.11.7.3.1. A Flight Test Plan is a set of step-by-step procedures that the crew member will use during the actual flight test. These procedures must be precisely written so that there is no operator confusion. (It is best to avoid a mission being scrubbed because of a problem with the test plan.) The AFNWC and Sandia engineers may have the opportunity to review the procedures with the crew member before the flight; however, this may not occur if it interferes with the required crew rest period before the flight test. An accurate Flight Test Plan is beneficial in two ways:

4.11.7.3.2. It makes crew debrief after the flight much easier because the procedures contain exactly what kind of indications the operator should see when going through the various AMAC operations. This is necessary because not all of the CTUs flown on the flight test may have the SE3331 tester installed to record what occurred at the interface.

4.11.7.3.3. On stations that do have an SE3331 configured CTU, it helps on the data reduction to determine if the aircraft and bomb are responding according to the commands given by the operator in flight.

4.11.7.3.4. Reducing the vast amount of data taken during a ground and air AMAC test can be very time consuming. The SWIFT test results are less time consuming than the SE3312 and SE3331 test results, because the program is designed to show whether or not the data passes or fails when compared to the AMAC specification requirements. The SE3312 and SE3331 take longer to determine this because voltage, current, and time measurements are recorded as they occur on every pin at the System 1 interface. The sequence of recorded signals then has to be compared to the AMAC command and known weapon responses to that command. This has to be done for every AMAC command generated in the cockpit. Like in the SWIFT, there are analysis programs for PAL, USG, and CD in both the SE3312 and SE3331 programs that show when the specification requirements are not being met. This part of the program helps reduce data reduction for these pulse measurements; however, a significant amount of data that has to be reviewed one line at a time still remains.

4.11.8. **Conducting AMAC Tests.** Both the AFNWC and SNL create test plans and publish test results of AMAC tests. Test results are reported to outside agencies, document what conclusions were drawn, and what capabilities were granted based upon the test data and the approved FDAR and EICDs.

4.11.8.1. If the aircraft fails to meet any part of the AMAC specification, the AFNWC and SNL engineers must inform the AMAC designer and the government agency in charge of the program so that the problem can be remedied. First, it must be determined if the AMAC design can be fixed to meet the specification. If this is not possible because of program cost considerations, or for any other reason, the Sandia engineer will probably be asked to verify that the weapon(s) carried by the aircraft will work properly in the area that is out of specification limits. Sandia's B61 and B83 Weapon Departments can assist with this kind of problem. The Sandia Aircraft Compatibility Department also has data in its files that define past problem areas. This documentation can be found in the various aircraft and weapon archive files. Depending on the complexity of the problem, a limited capability or no capability at all may be stated in the ACCD(s).

4.11.8.2. Periodically, after the five aircraft AMAC tests, the aircraft may undergo software and/or hardware changes that may affect the AMAC system. These changes are documented in updates to the FDAR. The Sandia engineer determines if the changes are significant enough to warrant follow-on AMAC testing to confirm the analysis in the FDAR. If a change is minor and no AMAC testing is necessary, a capability can be granted by adding it to the appropriate ACCD. However, in the case of having a new version of software listed in the MNCL, AMAC testing, conducted by the AFNWC, is required. When testing is necessary, the Sandia engineer will work with the AFNWC to create a ground and/or air test plan(s) that defines what needs to be accomplished. If changes to the AMAC system are few, testing may be required/requested by Sandia every 5 to 10 years on at least two aircraft. This is AMAC testing in addition to the surveillance testing conducted annually by the AFNWC. This 5 to 10 year timespan is based on what the Sandia Aircraft Compatibility Department has done in the past, and it fits in well with updates made to the aircraft. Both ground and flight tests are to be accomplished using the SWIFT, SE3312, and SE3331 testers. The purpose of these tests is to verify that no degradation to the AMAC system has occurred that would cause the aircraft to fail to meet the AMAC specification requirements. A failure due to degradation may jeopardize the aircraft's capability as stated in the ACCD(s) and possibly in the MNCL.

4.11.8.3. AMAC tests are also performed on a new weapon or a modification to an existing weapon. For these situations, an AMAC test is conducted using the SWIFT and SE3312 for the ground tests and the SE3331 for the flight test. Upon successful completion of these tests, the weapon is added to the ACCD. There is also the situation where the Sandia B61 and B83 Weapon Departments determines that a modification to an existing weapon is so minor that it is added to the ACCD without any AMAC testing accomplished. Table A.4. provides a checklist to aid the AFNWC and Sandia engineers to determine when and what kind of AMAC electrical tests are required based upon the type of changes made to the aircraft platform.

4.11.8.4. Besides conducting AMAC electrical tests on aircraft, there are also various AMAC test facilities available to conduct tests and each have a very specific purpose and level of fidelity. AMAC Laboratories at the AFNWC and SNL are used to check out the SWIFT and SE testers prior to shipping equipment to a base. System Integration Labs (SILs) are located at various aircraft contractor facilities and Air Force Bases responsible for developing or maintaining aircraft weapon systems. These SILs are used as a means to conduct development tests on new software not yet released to the field, as well as final verification of aircraft software before it is released for operational use. SILs are useful facilities for checking out development software to determine if the software integration with AMAC hardware will function properly and meet AMAC specifications. Some SILs use nuclear weapon simulators to provide simulation of a nuclear weapon. On occasion they have also requested the loan of Sandia CTUs to verify proper operation of weapon components. In general, SILs are not used in place of aircraft for certification or surveillance testing. They do not represent the entire aircraft as far as electrical loads, power supplies, or total number of nuclear weapon store mechanical or electrical configurations. However, there are cases when a small OFP change doesn't need a full aircraft test and a regression test is all that is needed. In that case, with Sandia concurrence and participation, a regression test is conducted in a SIL and used as part of the basis for certification.

4.12. **Electromagnetic (EM) Test and Analysis.** *Modern military aircraft are exposed to a very complex electromagnetic environment. Onboard sources include UHF and VHF communication transmitters, radars, and electronic warfare equipment, such as Electronic CounterMeasures (ECM) pods. The aircraft may also be exposed to significant EM fields due to external sources such as radar and communication transmitters both on the ground and on nearby aircraft. In general, nuclear weapons are designed to be safe and reliable when exposed to a set of EM environments that are specified in the Stockpile-to-Target Sequence (STS). These environments include the EM exposure that a bomb will encounter when carried on the aircraft specified in the MCs. When a new aircraft is designed that has a requirement to carry nuclear weapons, the EM environments at weapon carriage points must be determined to verify that they are below the STS limits. Aircraft with an established nuclear weapon capability may have new equipment added to its store list and this new equipment may change the expected EM environments at nuclear weapon carriage locations. Again, the EM exposure that the weapons will see must be determined. Predictions of the electromagnetic fields expected at nuclear weapon locations due to radiators on new aircraft or new radiators on existing aircraft are usually generated by the military (by either a contractor or by a military engineering lab) based on radiator design parameters such as the peak and average power, antenna gain, and physical proximity to weapon locations. Sandia engineers may also perform some worst case calculations based on these same parameters. Finally, if the field strength predictions are remotely close to the weapon design limits, Sandia will then perform field strength measurements on real aircraft that have the radiators of concern installed. The ElectroMagnetic Measurements System (EMMS) operated by Sandia, uses sensors that have the physical characteristics of a B61 to measure the fields tests on the ground and in-flight. The data is acquired and processed real-time in the field, then stored for future analysis.*

4.12.1. The Sandia weapons systems engineering departments are responsible for assuring the weapon will work when exposed to the EM environments specified in the MCs and STS. They conduct tests and analyses, via support from Sandia's Electromagnetic Test and Plasma Physics Analysis Department, to assure a capability exists. This activity typically occurs during weapon development, resulting in this task being evaluated far in advance of any other ACCD task. The EM fields need to be reexamined whenever a new aircraft enters the stockpile or whenever changes to an existing aircraft occur. The reexamination may be limited to worst-case analysis if the fields are much smaller than the design limits. If the analysis shows that the field may have the same magnitude as the design limits, a test may be required. Testing is conducted by the Sandia Aircraft Compatibility Department using the ElectroMagnetic Measurement System (EMMS trailer and the B61 EMMS test units) or by the use of the B61 or B83 Electromagnetic Compatibility (EMC) load units. The EMMS uses two B61 shapes, instrumented with current skin probes, a power meter, and a spectrum analyzer, to convert skin current measurements into EM fields. One unit is exclusively used for ground measurements while the other is flight-certified. The EMC load simulators contain the correct electrical loads of the B61 or B83 gravity weapon so that the correct frequency responses can be replicated when conducting EMC tests. The units also interact with the aircraft AMAC system so that they can be placed in various AMAC states. The respective pullout cables are modified with a current probe and measurements are taken to obtain the direct current injection during an EMC test. The data measured by EMMS and EMC load simulators will indicate if a problem exists that would impact the weapon's compatibility with the aircraft's radiating equipment. When the tests are completed, Sandia reviews the data along with personnel from the weapon systems engineering and electromagnetic departments, and recommends how the ACCD should be written. Depending upon the test results, the ACCD will either be amended to list the new radiating equipment, or it will specify a limitation with this equipment when the nuclear weapon of concern is present.

4.13. **Full Weapon System Drop Test.** *Typically, full weapon drop tests are the last tests run before a recommendation is made to add an aircraft to a nuclear bomb ACCD. The purpose of these tests is to exercise the whole weapon system from beginning to end. Sandia and the DOE provide a bomb test unit that, as nearly as possible, duplicates the features of a real WR bomb. In recent times, Joint Test Assemblies (JTAs) have been used in these tests. The test units are transferred to an operational branch of the military who then handle the weapon as if it were real. It is necessary to use operational nuclear certified aircraft, maintenance crews, weapon loading crews, flight crews, and Technical Orders. The military crews are given the task of delivering the test unit to a target. The target is typically an instrumented test range, such as Tonapah Test Range, where the delivery parameters of the weapon can be measured as the weapon separates from the aircraft and falls to the target. The analysis and testing discussed in the other sections of this report test only individual features or components. This is the only test that evaluates the entire system.*

4.13.1. The unit or units deployed here have been either JTA units or bomb project supplied Full Weapon System Drop Test units. Full Weapon System Drop Test units may not be available due to hardware availability. If they are available from Sandia's Weapons Departments, they may be called Interface Demonstration Units (IDUs) or Flight Test Units (FTUs). These units are very similar to JTA units, except they are not "scored" on the accuracy of the drop and they are not taken out of the stockpile.

4.13.2. This test is **very** important, because it is the final task for the requirements to release an ACCD. It is the most realistic test of the STS and is done to ensure everything (aircraft and weapon) works correctly. It is required because all other ACCD tasks focus on a specific part of the overall aircraft/weapon system. For example, an AMAC test checks only that portion of the aircraft that safes and prearms the weapon, because it is the System 1 or 2 specification area of concern. Other tasks described in this Handbook are concerned with the following during this test:

Aerodynamic loading on the bomb because of various flight conditions

Individual bomb components and the assembly as a whole reliably operating in the

environments to which they are exposed, and

Bomb interfacing properly with the aircraft.

4.13.3. These tasks do not consider the following areas of DoD's responsibility, which are accomplished during this task and the follow-on JTA Program:

Delivery accuracy of the aircraft,

Weapon loading and handling aspects, or

Adequacy of the Technical Order (TO) procedures written for aircraft and crew operations

Simulated end-to-end PAL code release.

4.13.4. The JTA Program is managed by NNSA with Sandia and the DoD as major contributors. The DoD treats this test as a "scored" mission, meaning the crew is evaluated on their proficiency to deliver a nuclear weapon. Sandia's Stockpile Evaluation and Aircraft Compatibility Department is directly responsible for the JTA test. The Aircraft Compatibility portion of the Department helps the Stockpile Evaluation side understand how the aircraft AMAC systems work and what is unique about each one of the systems. If a failure in the test occurs, this Department analyzes the failure to determine if it was caused by the aircraft, the bomb, or the crew. A record of the JTA missions on the aircraft should be kept, because it provides a good database on what was tested.

4.13.5. In years past, it was possible to have a JTA mission on an aircraft whose AMAC software had yet to be included in the FDAR, ACCD, or tested by the AFNWC and Sandia. With the advent of the MNCL, a confirmation is now made by the AFNWC and Sandia, that the operational software, planned to be used for a JTA mission, is listed in the MNCL as officially approved software to be used with nuclear weapons.

4.13.6. On a totally new aircraft, it might be a better plan to have the bomb project groups provide B83 and/or B61 Full Weapon System Drop Test units for this ACCD task that will allow JTA activities to proceed on their own schedule.

4.13.7. The successful results of this task and all of the other tasks described in this chapter will result in the publication of the ACCD by Sandia's weapon systems engineering departments, and the publication of the NCCS by the AFNWC.

4.14. **Publish Statement of Compatibility (SOC), Aircraft Compatibility Control Drawing (ACCD), and/or Compatibility Certification (CC) Drawing.** *Publishing the SOC and releasing the ACCD and/or CC are the final certification tasks performed by SNL. The SOC is an SNL/NNSA letter to the AFNWC documenting the nuclear weapon system compatibility with a specific weapon. After the SOC is submitted to the AFNWC, then the addition of the aircraft to the appropriate weapon's ACCD or CC is accomplished. The ACCD is a document that is referenced by the Major Assembly Release (MAR) for each nuclear gravity bomb and addresses compatibility with the carrier aircraft designated by the Military Characteristic (MC) or Stockpile-to-Target Sequence (STS). The ACCD for a given bomb contains a listing of the aircraft that have been granted a capability with that bomb and a tabulation of conditions and restrictions for loading and carriage. The addition of an aircraft to an ACCD means that Sandia and the NNSA are satisfied that carriage and release of the bomb on that aircraft will not affect the reliability numbers assigned to the bomb in the MAR; i.e., the aircraft meets all the electrical and mechanical requirements to carry the bomb, and the environments that the bomb will experience while on the aircraft are within* *those described in the current bomb STS. Once the Sandia Aircraft Compatibility Department makes its recommendations, the ACCD is published by the appropriate weapon systems engineering department. An established ACCD is only published once a year. For interim requests, a letter is sent to the AFNWC informing them of recommendations to the ACCD. This serves as an official Statement of Compatibility until the ACCD is formally updated. The CC is a control drawing prepared and maintained by Sandia which establishes the extent of compatibility and restrictions between a nuclear warhead on an Air Launched Cruise Missile (ALCM) and an USAF aircraft. The CC is released after the compatibility tasks have been successfully completed. The CC is maintained by the SNL W80 weapon department. The MAR is a NNSA statement that WR weapon material is satisfactory for release to the Department of Defense (DoD) for specified capabilities and uses. Its publication is defined by SNL Technical Business Practice TBP-001, which establishes role and responsibilities and provides procedures for the MAR system. The MAR is prepared by Sandia National Laboratories and the appropriate physics laboratory (either Los Alamos National Laboratory or Lawrence Livermore National Laboratory) and is approved by NNSA. The MAR may be qualified by limitations and exceptions. The MAR is also published by the Defense Threat Reduction Agency and distributed to the military services in a joint service technical manual.*

4.14.1. To issue or reissue the MAR, several high-level signatures are required. The ACCD and CC are referenced in the appropriate MAR, and were created to allow changes in aircraft or naval ship capabilities to occur without all the signatures required by the MAR. Each ACCD and CC is "owned" by the appropriate Sandia weapon engineering departments. When changes are required, either additions or deletions, the Sandia Aircraft Compatibility department prepares a memo to the appropriate weapon department outlining the changes and the rationale for those changes. They prepare the change paper and the Sandia Aircraft Compatibility department signs off on the final ACCD or CC.

4.14.2. Each active nuclear weapon MAR, ACCD, and CC is listed in the tri-service 50-7 technical manual.

4.15. **Publish Aircraft Nuclear Compatibility Certification Statement (NCCS).** *The final task required by the nuclear compatibility certification process is the AFNWC's Nuclear Compatibility Certification Statement (NCCS). It is issued by the AFNWC/498 NSW/NWAS when all aspects of compatibility certification are accomplished. It is a formal document prepared by the Lead System Engineer, and approved by the Section Chief, Division Chief, and Wing Commander. A NCCS is released for each aircraft capable of delivering nuclear weapons. It documents the nuclear weapon system configuration, carriage/delivery parameters, test information, operational restrictions if required and references pertaining to compatibility of the aircraft system with the nuclear weapons. The NCCS seeks to define the configuration (Hardware, Software, Suspension and Release equipment, Technical Orders) ,of the nuclear aircraft to ensure successful carriage and launch/release of a nuclear weapon. Items listed have been tested and/or evaluated for nuclear compatibility certification. This configuration information defines the National Item Identification Number (NIIN), Computer Program Identification Number (CPIN) for software, and descriptive nomenclature. For a complete listing of all nuclear certified* *hardware, software, support equipment, and Technical Orders, consult the Master Nuclear Certification List. The structure of the NCCS is as follows:*

Section I: Aircraft System General Information

Section II: Aircraft Monitor and Control System (AMAC) Components

Section III: Suspension and Release Equipment

Section IV: Compatible Weapon/Equipment Configurations

Section V: Carriage and Employment Limitations

Section VI: AMAC Testers

Section VII: Appendix (to include: A: Historical AMAC Testing, B: Nuclear Certification Documents Reference, C: Nuclear Certified Technical Orders and D: Open Issues and Restrictions)

4.15.1. The NCCS is a very important document in the overall nuclear certification process. Written as an unclassified FOUO document, it is released in accordance with AFI 63-103, *Nuclear Weapons Life Cycle Management*. What it is, and how it fits in with the overall nuclear weapon system's certification process, is defined in AFI 63-125, *Nuclear Certification Program.* The NCCS affirms that aircraft, bomb, and cruise missile systems meet all nuclear compatibility criteria according to results gained from engineering analysis and data reduction from all tests conducted. Each Section builds upon the data of the other sections. To keep the NCCS unclassified, each section contains references to TOs where classified data can be found. When writing each section, there are some important items to include. The following is a list of the types of information to be included in each Section. Additional aircraft specific information, pertinent to nuclear weapon compatibility certification, may be provided in the NCCS.

4.15.1.1. Section I, Nuclear Aircraft System General Information, includes the aircraft nomenclature, the type of propulsion, what nuclear weapons it can carry, and what are the nuclear certified stations.

4.15.1.2. Section II, AMAC Components, includes the hardware and software nomenclature, part/dash numbers, NIIN, and CPIN identifying numbers.

4.15.1.3. Section III, Suspension and Release Equipment, includes pylons, rotary launchers, bomb rack nomenclature, part/dash and NIIN numbers, orifice size, ejection velocities, explosive cartridge configurations, and suitable substitute cartridges.

4.15.1.4. Section IV, Compatible Weapon/Equipment Configurations, includes weapon type, pullout cable nomenclature, fin configuration, delay timer settings for parachute and spin rockets, configurations with nuclear weapons and other adjacent stores (fuel tanks, dispensers, pods, air-to-air missiles, etc.).

4.15.1.5. Section V, Carriage and Employment Limitations, includes weapon loadouts, min/max airspeed and altitudes.

4.15.1.6. Section VI, AMAC Testers, includes any pre-load and certification testers used to verify the AMAC interface on the aircraft before a nuclear bomb or missile is loaded on the aircraft. This includes the tester's nomenclature, part/dash numbers, CPIN, and NIIN numbers.

4.15.1.7. Section VII contains the Appendices for specific reference information.

4.15.1.7.1. Appendix A, Historical AMAC Testing, covers both certification and surveillances tests. Dates of the tests, base location, aircraft tail numbers, and AMAC software version tested are listed. Results of the tests, including any Product Quality Deficiency Reports, and Conclusions to state compliance to the AMAC specifications are included for historical purposes.

4.15.1.7.2. Appendix B, Nuclear Certification Documents Reference, lists the titles of all applicable safety and compatibility documents and their date of release. This includes the Nuclear Safety Analysis Report (NSAR), the AMAC Final Design Approval Report (FDAR), the Electrical and Mechanical Interface Control Drawings (EICD and MICD), and applicable Aircraft or Compatibility Certification Drawings (ACCD and CC). This is also a good location to list the versions of AMAC specifications that the aircraft was originally built to. This is helpful to know when AMAC surveillance testing finds discrepancies in test measurements compared to AMAC specification requirements. Because the current weapon stockpile has lighter loads compared to weapon loads of retired systems, there has been a change to the AMAC spec loading defined in the current specification. Tested AMAC circuits not meeting the current specification, could be an explanation as to why certain lines are showing discrepancies. The F-15E Category D PAL total pulse period limit is a good example.

4.15.1.7.3. Appendix C, Nuclear Certified Technical Orders, includes, but is not limited to, titles to all aircraft ground and in-flight Operating TOs, nuclear weapons aircraft mate and demate TOs, Aircrew delivery procedures (nuclear weapons and trainers), ejector rack, maintenance, and tester manuals.

4.15.1.7.4. Appendix D, Open Issues and Restrictions, defines any carriage restrictions, max load configurations, degradation of AMAC circuits found during surveillance testing, and any other noted limitation or finding.

4.15.2. It is important to keep all of these Sections up-to-date with the latest information. It is good for the author of the NCCS to review all Sections prior to the signoff of a new version of the NCCS, to make sure there is nothing that is out-of-date and all information is current and all Sections are complete. In addition, in the preliminary stages of updating the NCCS, it is important to perform a cross-check of configuration information supplied by the System Program Manager, to the information in the MNCL. This helps the MNCL be an accurate representation of what is allowed in the field.

4.16. **Publish Master Nuclear Certification List (MNCL).** A *domain controlled web-site data base that identifies equipment (hardware and software) that is nuclear certified per AFI 63-125. The MNCL is the sole authority for determining equipment certification status, and is managed by the AFNWC's certification management organization.*

4.16.1. After the Nuclear Compatibility Certification Statement (NCCS) has been released signifying the satisfactory completion of the nuclear certification process, the MNCL is updated. The NCCS is source document for the MNCL; therefore, this update to the MNCL is based on software, hardware and support equipment items listed in the NCCS. The MNCL is the sole source used to verify nuclear certification. It is a web-based tool designed to define the hardware, software, technical data, configuration, and other information that is encompassed within the definition of nuclear certification. Its purpose is to enable users to identify nuclear certification status of a weapon system, sub-system, component, software, or support equipment.

4.17. **Other Topics of Interest.**

4.17.1. **Compatibility Reports.** The Sandia Aircraft Compatibility Department has Sandia Reports on each aircraft which documents how all of the ACCD tasks have been accomplished. These reports provide a quick reference for all of the correspondence and testing that took place to accomplish an ACCD release. Without these reports, it takes a considerable amount of time to "dig up" the information contained in many different files over a long time span. These reports benefit those organizations at Sandia and the AFNWC responsible for nuclear certification. These reports are available from the Aircraft Compatibility Department and Sandia's technical library.

4.17.2. **AMAC Simulators Used by Sandia and the AFNWC.** The need for AMAC simulators was established in the 1960s so that the Sandia Aircraft Compatibility Department would have the capability to support the variety of aircraft-related projects at Sandia. These are especially designed simulators that represent the AMAC system in the aircraft. Real AMAC hardware is used whenever possible to create an AMAC interface that responds to, and has the same electrical characteristics, as the real system.

4.17.2.1. Currently all real USAF AMAC hardware in custody of Sandia is accountable material in the USAF Nuclear Weapons-Related Materiel (NWRM) system. On software-based integrated systems like the B-2A, F-15E, and F-16A/B/C/D aircraft, it is difficult to get the real hardware, because not as many spares were procured by the USAF and so much of the AMAC system is software driven. It is also difficult to get and maintain the actual software used on the aircraft. In these situations, similar hardware is built and software is written to respond accordingly. This was done for the B-2A, F-15E, F-16A/B/C/D AMAC simulators. Sandia has received the necessary USAF equipment to build a B-52H CSRL AMAC system, and is currently planning on having it built in the FY12 timeframe. Sandia, and the AFNWC, also have AMAC simulators for the PA-200 and F-111E aircraft. Even though the F-111E has been retired from the inventory, the simulator is a useful tool for checking out the SWIFT tester in the laboratory prior to surveillance and compatibility certification tests. It simulates the PAL, USG, CD, and other System 1 interface signals similar to other System 1 aircraft in the inventory. The AMAC simulators are also used for demonstration and training purposes for nuclear weapon delivery simulation using the SMU-105/C nuclear weapon interface simulator which is described below.

4.17.2.2. The following list represents the type of usage the AMAC simulators have seen over the years. Various aspects of these of activities are still occurring today.

SWIFT Tester and CTU checkout prior to an AMAC test,

New weapon development support,

Stockpile improvement support,

Development of new PAL Command and Control designs,

Development of new AMAC controllers for existing aircraft,

DTRA Defense Nuclear Weapons School (DNWS) training,

DoD AMAC tester development,

DoD nuclear weapon simulator development,

Military liaison nuclear weapon delivery training,

JTA mission planning and problem solving,

NWSSG studies,

UR investigations, and

TO verification.

4.17.2.3. The AFNWC have developed a System 2 Workstation in preparation of the F-35 and other MIL-STD-1760 capable aircraft platforms that will at some point in time, add the System 2 interface for future Digital Interface needs.

4.17.3. **Aircraft Nuclear Weapon Training Devices Used by the USAF.** Since real nuclear weapons cannot be used for air crew training, the USAF and NATO services have a variety of gravity nuclear weapon training devices available. Early devices known as Bomb Dummy Units (BDUs) were developed by the DoD to represent the size, shape, and weight of a real nuclear weapon to provide delivery training, but without any logic to simulate the electrical function of the weapon. In the 1960's USAF added a handheld simulator known as a "sim plug" to the inventory, and is still in use today on F-16 aircraft. The plug is connected to the AMAC interface and provides limited safe and prearm monitor responses back to the cockpit. The sim plug was used in conjunction with BDU drops. There are also versions of BDUs, and another weapon shape known as a Type 3E, that are used for loading and handling training. These units provide the ground crews with training in this area and a safe indication in the cockpit as a real weapon would once it was connected to the AMAC interface via the bomb's pullout cable. The Type 3E units also provide training to the DoD PAL teams responsible for ground PAL controller operations at the weapon's preflight panel.

4.17.3.1. The USAF has the SUU-20/A bomblet dispenser in the F-16 inventory. This dispenser can release six bomblets off one station, which benefits repeated training on the same mission rather than a onetime only mission with a BDU. The bomblets have the same ballistics to test delivery accuracy as a nuclear weapon, and the dispensers provide some additional bomb indications over the sim plug design. The NATO countries use BDU's provided by the USAF for delivery training. They have their own version of a bomblet dispenser known as the CBLS200. The CBLS200 on the PA-200 aircraft is used with the SMU-105/C.

4.17.3.2. In 1979, the Sandia Aircraft Compatibility Department had system responsibility to build a small, handheld, bomb interface simulator for Sandia. It was eventually designed to simulate the bomb and pullout cable electrical features for all mods of the B28, B43, B57, B61, and B83 bombs in a single unit. These features included four and six digit PAL, USG, and CD. The bomb interface simulator accomplished the following:

It responded to seven unique unclassified PAL codes,

It simulated the bomb's Ready/Safe switch cockpit indications,

It was designed to interface with all System 1 AMAC aircraft in the inventory,

and

It had the capability to accept a release signal and reset itself once the AMAC

returned to the Off state.

4.17.3.3. The German and Italian NATO PA-200 Tornado program found this device to be an ideal nuclear weapon delivery trainer, and ordered it in 1981. They also ordered a field tester to perform functional tests on the simulator before use on the aircraft. The DoD eventually designated the simulator as the SMU-105/C and the field tester as the TTU-412/C. Subsequent to this NATO order, the USAF placed orders for this hardware to support their training programs. Orders were also placed for a variety of cables to be used with the SMU-105/C for simulating release, and for using the SMU-105/C in conjunction with BDUs and bomblet dispensers.

4.17.3.4. The USAF has implemented software simulation of nuclear weapon AMAC responses into their integrated AMAC systems on the F-16A/B/C/D, F-15E, B-52H with CSRL, and B-2A aircraft. This software simulation provides air crew training, but it does not exercise the entire AMAC system from cockpit commands to the System 1 interface like the SMU-105/C. This aspect of the SMU-105/C verifies the weapon release software designed by the aircraft contractors for these aircraft for the USAF.

4.17.4. **Helpful Information to Understand Nuclear Compatibility Tasks.** Attachment 2 contains a chart showing what historically has been the minimum time needed by Sandia to complete the tasks necessary to get to a Weapon Capability Date (WCD). Minimum times should only be used when time is of the essence in order to meet a WCD. The WCD is the date the user says they can carry nuclear bombs on the aircraft. Sometimes the WCD is called a Rules Need Date (RND). The ACCD/CC and NCCS must be released prior to or in conjunction with the WCD.

4.17.4.1. Attachment 3 contains an outline of a nuclear bomb compatibility test program. These charts show who is responsible for accomplishing the many tasks necessary to grant a nuclear capability in an aircraft program. It outlines the following:

What the item is,

What is needed and by who,

What data is to be obtained,

Who does the analysis, and

What other requirements are needed for each specific item.

4.17.4.2. These charts are helpful when explaining to Sandia weapon departments, the DoD, NATO, and the aircraft contractor what the level of effort is and who is expected to participate to have a capability with a nuclear weapon on an aircraft.

4.17.4.3. Table A.4. provides a checklist to aid the AFNWC and Sandia engineers to determine when and what kind of AMAC electrical tests are required based upon the type of changes made to the aircraft platform. Similar data can be found in the System 1 AMAC Test Requirements document SYS 1300-02 dated 20 May 2005, and the draft System 2 AMAC Test Requirements document SYS 2300-00 dated June 2007.

4.17.4.4. Table A.5. provides a checklist to aid the AFNWC and Sandia engineers to determine when and what kind of mechanical tests are required based upon the type of changes made to the aircraft platform.

5. Training. Listed below are excellent courses offered by SNL, DTRA, and the AFNWC that are beneficial to staff working aircraft compatibility certification programs:

5.1. Air Force Nuclear Certification Process Course offered by the AFNWC, Kirtland AFB, NM

5.2. AF Nuclear Management Fundamentals Course offered by the AFNWC, Kirtland AFB, NM

5.3. WR708: Survey of Weapons Development and Technology offered by SNL, Kirtland AFB, NM

5.4. WR712: Operation of the Nuclear Weapons Complex offered by SNL, Kirtland AFB, NM

5.5. WR713: Engineering Guide to Nuclear Weapons Development, Production, and Stockpile offered by SNL, Kirtland AFB, NM

5.6. NWOC: Nuclear Weapons Orientation Course offered by the DTRA Defense Nuclear Weapons School, Kirtland AFB, NM

GARRETT HARENCAK, Brigadier General, USAF
Commander, Air Force Nuclear Weapons Center

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

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Prescribed Forms

None

Adopted Forms

AF Form 399, *Request for Action on Implementation of Higher Headquarters Publications*

AF Form 673, *Air Force Publication/Form Action Request*

AF Form 847, *Recommendation for Change of Publication*

AF IMT 1768, *Staff Summary Sheet*

DD Form 67, *Form Processing Action Request*

GPO Form 952, *Desktop Publishing Disk Information*

GPO Form 3868, *Notification of Intent to Publish*

Abbreviations and Acronyms

AC—Alternating Current

A/C—Aircraft

ACCD—Aircraft Compatibility Control Drawing

AF&F—Arming, Fuzing, and Firing

AFI—Air Force Instruction

AFMAN—Air Force Manual

AFNWC—Air Force Nuclear Weapons Center

AL—Albuquerque Liaison Office

ALCM—Air Launch Cruise Missile

AMAC—Aircraft Monitor And Control

APU—Auxiliary Power Unit

A/V—Air Vehicle

BDU—Bomb Dummy Unit

CC—Compatibility Certification

CD—Command Disable

Cg— **-** Center of gravity

Config— **-** Configuration

CPIN—Computer Program Identification Number

CSRL—Common Strategic Rotary Launcher

CTU—Compatibility Test Unit

DC—Direct Current

DoD—Department of Defense

DOE—Department of Energy

DT&E—Developmental Test and Evaluation

DWG—Drawing

ECCD—Electrical Compatibility Control Drawing

ECM—Electronic Counter Measure

EICD—Electrical Interface Control Drawing

Elec— Electrical

EM—ElectroMagnetic

EMC—ElectroMagnetic Compatibility

EMMS—ElectroMagnetic Measurement System

Equip— **-** Equipment

ESDD—Electrical System Description Drawing

FDAR—Final Design Approval Report

FTU—Flight Test Unit

GND—Ground

Hz— - Hertz

HQ—Headquarters

HW—Hardware

IDU—Interface Demonstration Unit

IMF—Integrated Maintenance Facility

INWS—Interservice Nuclear Weapons School

JTA—Joint Test Assembly

MAR—Major Assembly Release

MC—Military Characteristics

MCCD—Mechanical Compatibility Control Drawing

Mech— - Mechanical

MICD—Mechanical Interface Control Drawing

MNCL—Master Nuclear Certification List

MOU—Memorandum of Understanding

NATO—North American Treaty Organization

NCCS—Nuclear Compatibility Certification Statement

NCE—Nuclear Certified Equipment

NCI—Nuclear Certififed Item

NIIN—National Item Identification Number

NNSA—National Nuclear Security Administration

NSD—Nuclear Systems Division

NSG—Nuclear Systems Group

NWI—Nuclear Weapons Integration

NWRM—Nuclear Weapons-Related Materiel

NWSSG—Nuclear Weapon System Safety Group

PAL—Permissive Action Link

PDR—Preliminary Design Report

PLS—Prearm Load Simulator

POG—Project Officer's Group

POM—Project Officer Meeting

Prelim— - Preliminary

Prod— **-** Production

PSD—Power Spectral Density

q - Dynamic pressure

RND—Rules Need Date

SAC—Strategic Air Command

SIL—System Integration Laboratory

SLCM—Sea Launch Cruise Missile

SNL—Sandia National Laboratories

SOC—Statement Of Compatibility

SPO—System Program Office

SRAM—Short Range Attack Missile

Struct— Structural

STS—Stockpile-to-Target Sequence

SWIFT—Special Weapons Interface Tester

T/M—Telemetry

TO—Technical Order

UR—Unsatisfactory Report

USAF—United States Air Force

USG—Unique Signal Generator or Generation

USN—United States Navy

VATU—Vibration-Acoustic Test Unit

VFA—Vibration Flyaround Assembly

VIPER—VIbration PErformance Recorder

WCD—Weapon Capability Date

WES—Weapon Electrical System

WL—Weapons Laboratory

WR—War Reserve

WSECCD—Weapon System Electrical Compatibility Control Drawing

Terms

Aircraft Compatibility Control Drawing (ACCD)— Each nuclear weapon is issued a Major Assembly Release (MAR). The part of the MAR that describes aircraft compatibility is called the ACCD. The ACCD establishes the extent of compatibility and restrictions between the nuclear weapon and the aircraft.

Compatibility Certification Drawing (CC)— A control drawing prepared and maintained by Sandia which establishes the extent of compatibility and restrictions between a nuclear warhead on an Air Launched Cruise Missile and an aircraft, or a nuclear warhead on an USN Sea Launched Cruise Missile on a naval ship. The CC is released after the compatibility tasks have been successfully completed. The CC is maintained by Sandia.

Major Assembly Release (MAR)— A Sandia-prepared, NNSA-approved statement that DOE stockpile weapon material is satisfactory for release on a designated effective date to the DOD for specified capabilities and uses that are qualified by limitations and exceptions to the MC and STS requirements. Compatibility must be evaluated with each of the carriers (aircraft) designated by the STS or MC. The ACCD (gravity bombs) and the CC (warhead) are subsets of the MAR. All nuclear weapons have a MAR.

Military Characteristics (MC)— The MC is a document that defines the using service's requirements for a specific nuclear bomb/warhead. It describes the required bomb yields and fusing options, warhead parameters and general information concerning operational, physical, functional, environmental, vulnerability, safety, reliability, maintenance, monitoring, storage and handling considerations, and sets forth the design compliance priorities in the event of conflicting design requirements.

Nuclear Compatibility Certification Statement (NCCS)— The NCCS is a document that is written for each aircraft platform that has been certified to carry nuclear weapons. It defines general information about the aircraft system, Nuclear Certified Equipment (NCE), and approved software. The nuclear weapon system configuration, carriage/delivery parameters, any restrictions, and certification and surveillance AMAC tests conducted to date. The NCCS is kept up-to-date and is released in accordance with AFI 63-103, Nuclear Weapons Life Cycle Management.

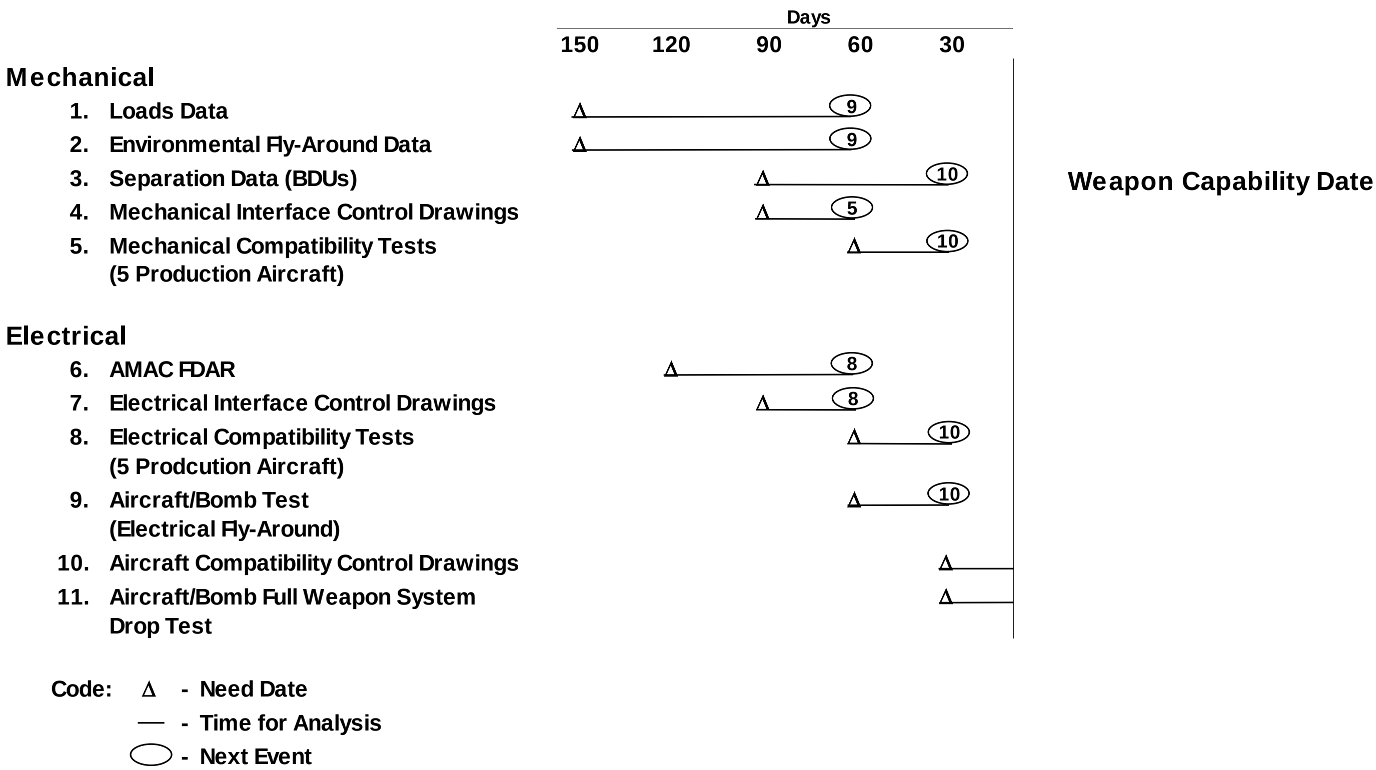
Stockpile-to-Target Sequence (STS)— The STS is a service generated document that defines the operational and logistical concepts and related physical environments involved in delivering a nuclear weapon from the stockpile to the target. It also defines the logistical flow involved in moving and recycling nuclear material to and from the user to stockpile. The STS furnishes the NNSA with a set of design requirements that amplify the MC's by providing additional detailed guidance necessary for development of a nuclear weapon. The STS provides detailed information in such areas as stockpile storage temperatures and durations, logistic movement, vibration and shock environments, specific aircraft carriage configurations, aircraft carriage sound pressure levels, soak temperatures, delivery profiles, etc.

Master Nuclear Certification List (MNCL)— The MNCL is a web-based tool designed to define the hardware, software, technical data, configuration, and other information that is encompassed within the definition of nuclear certification defined in AFI 63-125. Its purpose is to enable users to identify nuclear certification status of a weapon system, sub-system, component, software, or support equipment.

Attachment 2

MINIMUM TIME TO WEAPON CAPABILITY DATE

Figure A2.1. Minimum Time for Completion of Compatibility Tasks Prior to Weapon Capability Date



Attachment 3

OUTLINE OF A NUCLEAR BOMB COMPATIBILITY TEST PROGRAM

A3.1. Ground Tests

Wind Tunnel
Static Drops
Mechanical Fit
Electrical Function

A3.2. Flyaround Tests

Lug and Sway Brace Loads
Vibration
Thermal
Electrical Function

A3.3. Air Drop Tests

Dynamic Drops
Full Weapon System Drops

Table A3.1. Ground Tests

ITEM	NEEDED	DATA TO BE OBTAINED	ANALYSIS BY	OTHER REQUIREMENTS
1. Wind Tunnel	US or C Wind Tunnel US or C Aircraft & Pylon Models US or SNL Bomb Models	Loads Data on Bombs	US, SNL & C	US Config and Mixes
2. Static Drops	US or C Ejector Rack US or C Test Facility US or C Weighted & cg Test Units	Pitch Ejection Velocity Recommended Cart & Orifice	US or C	US or C Data to be Integrated into Wind Tunnel Separations and Used Later in Air Drop Test Program
3. Mechanical Fit	a) C Mock-up or Pre-Prod C or SNL Shapes (BDU's or CTUs) SNL System 1 Pullout Cables	Clearances and Serviceability	US, SNL & C	C Mech Layouts or Prelim Mech Interface Control Drawing (MICD)
	b) US or C Prod A/C SNL CTUs & System 1 Cables US Load, Checkout Equip and Crew	Verification of Fit Plus: AF-16 T.O.'s	US, SNL & C	US or C Completed Mech Interface Control Drawing (MICD) AF or C - 16 T.O.'s (Blue Line)

Code: C = Aircraft Contractor; SNL = Sandia National Labs; US = Using Service (USAF or NATO); AF = U.S. Air Force

4. Electrical Function of EM Equip on A/C (may not be required depending on adequacy of data supplied)	US or C Prod A/C with EM Equip SNL EMMS or EMC units & System 1 Cables US Load, Checkout Equip and Crew	EM exposure to Bombs	SNL	SNL Will Perform an Analysis if a problem exists that would impact the weapon's compatibility with the aircraft's radiating equipment
5. Electrical Function of AMAC	a) C Mock-up or Pre-Prod A/C SNL CTUs & System 1 Cables AF & SNL Record & Test Equip	Prelim Verification of AMAC Spec Verify Quality of Elec Signals to Bombs	US, AF, SNL & C	US or C Prelim Submittal of Preliminary Design Report (PDR)
	b) US or C Five Prod A/C SNL CTUs & System 1 Cables US Load, Checkout Equip & Crew AF & SNL Record & Test Equip	Verify Compliance with Appropriate AMAC Specs and Quality of Elec Signals Between Bomb and A/C Plus: AF-16 T.O.'s	US, AF, SNL & C	US or C Final Design Approval Report (FDAR) and Elec Interface Control Drawing (EICD) AF or C-16 T.O.'s (Blue Line)

Code: C = Aircraft Contractor; SNL = Sandia National Labs; US = Using Service (USAF or NATO); AF = U.S. Air Force

Table A3.2. Flyaround Tests

ITEM	NEEDED	DATA TO BE OBTAINED	ANALYSIS BY	OTHER REQUIREMENTS
1. Lug and Sway Brace Loads	If A.1 needs to be verified – SNL test unit or C instrumented bomb rack required For Additional Needs – Same as B.2 Vibration US or C Best Results Can Be Obtained with an "Instrumented" Aircraft for Data Correlation	Lug and Sway Brace Reactions at Various Flight Conditions and Maneuvers	SNL	Same Requirements as in B.2 Vibration
2. Vibration	SNL Units – T/M US or C Aero and Struct Equivalent Aircraft US or C Cockpit Elec to Control VFA Unit SNL Ground Station for Pre-Flight Checkout	Sample of the Vibration Environment of Certain Components Within Bomb During Specified Flight Conditions	SNL	US or C Will Provide A/C Flight Clearance SNL Needs: a) Wind Tunnel Loads Data; b) Aircraft Performance Data Tapes SNL Will Perform an Analysis to Determine Bomb Structural Adequacy Prior to These Flights
2. Vibration (Cont'd)	US or SNL Flight Test Area			

	US or C Load Checkout Equip & Crew	* These Units Can Be Reconfigured to Adapt to a Recorder Installed in the Aircraft or Carry the VIPER System.		
3. Thermal (may not be required depending on adequacy of data supplied)	US or C A Definition of Thermal Environment Imposed on Bombs	Data Sufficient to Create a Thermal Model of Weapons Bay with Doors Closed & Opened or on Pylon Superimpose Bombs in This Thermal Environment	SNL	Same requirements as in B.2 Vibration
4. Electrical Function of EM Equip on A/C (may not be required depending on adequacy of data supplied)	US or C Prod A/C with EM Equip SNL EMMS or EMC units & System 1 Cables US Load, Checkout Equip and Crew	EM exposure to Bombs	SNL US, SNL & C	Same Requirements as in A.4 Electrical Function
5. Electrical Function of AMAC (accomplish with A.3.b or A.5.b)	US or C Production Aircraft SNL Bombs and Cables US Load, Checkout Equip & Crew SNL Record & Test Equip	Observe Correct Operation Thru Prearm During Flights in Local Area Verify Proper Quality of Elec Signal to Bomb		Same Requirements as in A.5.b Electrical Function

Code: C = Aircraft Contractor; SNL = Sandia National Labs; US = Using Service (USAF or NATO); AF = U.S. Air Force

Table A3.3. Air Drop Tests

ITEM	NEEDED	DATA TO BE OBTAINED	ANALYSIS BY	OTHER REQUIREMENTS
1. Dynamic Drops	US or C BDU's or SNL FTU's US or C Aircraft with On-Board Cameras US or C Photo Chase and/or GND Cameras US or C Test Plan Based on Wind Tunnel Separation Tests	Full Scale Demonstrations Throughout Flight Envelope Desired by User Free Fall and Retarded Options	US, SNL & C	US or C Will Provide Flight Clearance and Decide on Progression to Next Data Point
2. Full Weapon System Drops	US or SNL Bombs & Cables US Production Aircraft SNL or US Test Range with Ability to Determine Trajectories US Load, Checkout Equip and Crew	Complete Weapon System Functional Tests Separation Ballistic Elec Interface AF&F All Options	US & SNL	US or C Will Provide Flight Clearance

Code: C = Aircraft Contractor; SNL = Sandia National Labs; US = Using Service (USAF or NATO); AF = U.S. Air Force

Table A3.4. Checklist For Electrical Compatibility Tasks

AIRCRAFT CHANGES (AMAC Electrical, Hardware, & Software)	**AMAC TESTS AND ANALYSES TO BE COMPLETED**				
	System 1 or 2 Specification Compliance	**Ground Functional of CTUs**	**Flight Functional of CTUs**	**Full Weapon System Drop**	**Engineering Analysis**
New Aircraft System or New Aircraft Variant	X	1, 2	1, 2	5	X
Major Hardware Modifications with Interface Impact	X	1, 2	1, 2	(5)	X
Minor Hardware Modifications with Interface Impact	(X)	1, 2			X
Hardware Modifications with No Interface Impact	(X)	(X)			X
AMAC Electrical Power Modification	X	1, 2	1, 2	(5)	X
Major Software Modifications with Interface Impact	X	1, 2	1, 2	(5)	X
Minor Software Modifications with Interface Impact	(X)	1, 2, 3, 4			X
Software Modifications with No Interface Impact	(X)	(1, 2, 3, 4)			X
No Changes to AMAC System for 5 - 10 years	X	1, 2	1, 2		X
1 Year Periodic Cycle	X	(1, 2, 3, 4)			X
New Weapon or	X	1, 2	1, 2	5	X

LEP Weapon					
AIRCRAFT CHANGES (AMAC Electrical, Hardware, & Software)	**AMAC TESTS AND ANALYSES TO BE COMPLETED**				
	System 1 or 2 Specification Compliance	**Ground Functional of CTUs**	**Flight Functional of CTUs**	**Full Weapon System Drop**	**Engineering Analysis**
Major Electrical Changes that Impact the Interface	X	1, 2	1, 2		X
Minor Electrical Changes that Impact the Interface	(X)	1, 2	1, 2		X
Electrical Change that do not Impact the Weapon Interface	(X)	(1, 2, 3, 4)			X
LEGEND	( )	Test is optional – to be required on case-by-case basis			
	X	No Compatibility Test Units Required			
	1	CTU-1			
	2	CTU-2			
	3	CTU-3			
	4	CTU-4			
	5	Full Weapon System Drop Test Unit			
	6	Aircraft Model			
	7	Bomb Model			
	8	BDU			

Table A3.5. Checklist for Mechanical Compatibility Tasks

AIRCRAFT CHANGES (Mechanical Hardware)	**MECHANICAL TESTS AND ANALYSES TO BE COMPLETED**				
	Wind Tunnel	**Static Drops**	**Mechanical Fit**	**Full Weapon System Drop**	**Engineering Analysis**
New Aircraft System; New Aircraft Variant	6,7	8	1, 2	5	X
Major Hardware Modifications with Interface Impact	6,7	8	1, 2	(5)	X
Minor Hardware Modifications with Interface Impact	(6,7)	(8)	(1,2)		X
Hardware Modifications with No Interface Impact	(6,7)	(8)			X
New Weapon or LEP Weapon	6,7	8	1, 2	5	X
LEGEND	( )	Test is optional – to be required on case-by-case basis			
	X	No Compatibility Test Units Required			
	1	CTU-1			
	2	CTU-2			
	3	CTU-3			
	4	CTU-4			
	5	Full Weapon System Drop Test Unit			
	6	Aircraft Model			
	7	Bomb Model			
	8	BDU			